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POISONS IN OUR ENVIRONMENT

AUGUST
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**SUSTAINABLE DEVELOPMENT POLICY INSTITUTE
ISLAMABAD, PAKISTAN**



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Prior to joining SDPI, Dr. Khwaja held teaching positions at the University of Peshawar, La Trobe University of Science and Technology, University of Cape Coast and Kumasi University of Science and Technology, Ghana. He worked as a subject specialist (science textbooks) with the Khyber Pakhtunkhwa Text Books Board and as a senior scientific officer with Pakistan Council for Scientific and Industrial Research.

Dr Khwaja has been SDPI lead investigator & focal person in several joint/collaborative projects/programs with partner organizations in Pakistan and Switzerland, Japan, Czech Republic, India, Republic of Korea, Belgium, Bangladesh and USA.

Dr Khwaja has over 80 publications to his credit, which have appeared in refereed national and international research journals, magazines and newspapers.

He holds honorary positions on executive committees of chemical societies, science associations, international networks like ISDE, PBC, IPEN, regional/international institutes and was member of UNEP steering group on chemicals in products (CiP) and regional/international institutes.

He actively participated in international negotiating committee (INC) meetings on Stockholm Convention on persistent organic pollutants (POPs), Minamata Convention on mercury, Strategic Approach to International Chemical management (SAICM) and international forum on chemical safety (IFCS).

He is life-member Chemical Society of Pakistan, past President of International Society of Doctors for Environment (ISDE) and winner of "Excellence in Research" and "Life Achievement" awards. In September 2019, Dr Khwaja was awarded Chairman's Trophy from Pacific Basin Consortium (PCB) on Environment and Health, for his contributions in research and support to PCB. He was instrumental in SDPI and All-China Environment Federation (ACEF), signing of MoU, recently, towards knowledge partnership, joint research and capacity building.

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POISONS IN OUR ENVIRONMENT
AND
WAY FORWARD

BY
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Dedicated to

My WIFE and ALL WORKING FEMALES

Who

Despite their Professional Excellence and Popularity, also share
“GREATER” part of the Household, Elderly and Children Responsibilities,
than their Husbands and Brothers.

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FOREWORD

The book in hand, “Poisons in our environment” is not merely another publication, but a diagnostic report of state of environment of our beloved homeland. The findings of Primary data collected from 38 selected sites in three provinces and Islamabad Capital territory of Pakistan reflect that dumping untreated industrial effluents; indiscriminate use of pesticides; and irresponsible dumping of pesticides are the major sources of soil and water contamination, affecting our environment. The evidences also establish that poor land use planning which allows industrial wastes to be dumped in residential areas, or allows conversion of dumping sites without their reclamation for residential and commercial use exposes human population to the above mentioned toxic wastes.

Case of a demolished DDT factory in Aman Garh (Nowshera, KPK) where, despite very high residues of DDT in the soil, neighborhood children used to play and the owner was planning to turn that site into a residential/commercial complex is one of the examples of how lack of awareness about toxic wastes may put human population vulnerable.

The book also highlights that lack of awareness about safe disposal of toxic wastes is not only prevalent in remote districts and peripheries, but Islamabad Capital Territory is not an exception. The authors have rightly pointed out that we do have National Environmental Quality Standards (NEQS) for industries in place. However, lack of appetite among industrial sector to implement those standards, lack of capacities among regulatory bodies to get those standards implemented, and lack of awareness among communities about the hazardous nature of industrial waste are the major root causes for environmental poisoning due to industrial waste.

I am thankful to Dr Mahmood Khwaja and his team for agreeing to synthesize their two decades’ experience of working on sustainable industrial production into this volume. The value addition of this book is that Dr Khwaja has not only diagnosed the problem in the light of his primary research and through a comprehensive review of earlier research on hazardous contaminants and polluted sites in Pakistan, but has also presented a very doable way forward.

Besides identifying highlighting the importance of updating the regulations for safe disposal of industrial contaminants and laws on use of polluted sites,

he has also provided a list of sites that according to his research should be reclaimed on priority basis.

While congratulating the author on completion of this volume, I am thankful to him for launching it on Sustainable Development Policy Institute (SDPI)'s 28th anniversary. Since its inception SDPI has been trying to catalyze the transition to sustainable development in the country, defines as “peace, wellbeing, and social justice across generations”. Without ensuring that our habitats are free of contaminants and pollution the dream of achieving sustainable development goals would remain unfulfilled.

I have no hesitation in saying that the kind of work presented in this book has kept SDPI relevant both among grassroots and in decision making/policy making corridors. Looking forward to the next book by Dr Mahmood Khwaja and his team.

Dr. Abid Qaiyum Suleri

Executive Director, SDPI,

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August 6, 2020

AUTHOR'S NOTE

Once I asked one of my very best and the most talented students, an excellent teacher and researcher of Analytical Chemistry, that why he does not write a book on Analytical Chemistry. His answer was prompt and simple: “Dr Sahib, when I could write a book on my subject, with only a pencil and papers on my table, I shall definitely write one, inshallah.” Obviously, he was talking of writing an original publication and not a book compiled from half a dozen books by other authors around.

The book, “Poisons in Our Environment” in hands may not meet the creative & originality standard of my very dear student (I am most proud of his very distinguished achievements), but it is a “Research-based” publication having the data (including contaminants in different environment segments), of 38 sites in the country’s three provinces, collected by the SDPI team, not only under my supervision & guidance but also in my presence at each of the visited sites.

I am so happy and grateful to Almighty Allah that finally, I was able to finish the book, which (subject to time availability) started in January 2019. *Alhamdolillah*

There is no commercial interest at all in writing and publishing this book. My motivation to continue work on it has been the hazardous sites & the exposure, resulting in the deteriorating environment and public health, especially that of children. It is very likely that this publication would sensitize national policy-makers as well as national and international donors for addressing this rapidly growing most alarming issue in Pakistan as well as across the world.

A few words about the book

All data described and discussed in the foregoing pages were acquired through field survey work by SDPI Team at sites, the analytical/laboratory tests reports on the samples collected at sites, of soil, solid/semi-solid wastes, drinking, surface/sub-surface water and through meetings /interviews with the affected local residents at sites and the stakeholders (government, industry, civil society & others). Chapter one also provides the summarized last more than 25 years reported/published research in the three provinces on the hazardous wastes/waste sites issue - a reliable/credible baseline reference data, for future work.

I have used some innovative approaches in chapters 2, 3 & 4, in describing and discussing the collected data to sensitize readers about the alarming situation. The last chapter describes “Way Forward” which includes overall findings of the study as well as the views expressed and the suggestions given by some of the main stakeholders.

I am most grateful to my fellow members of the SDPI team, Nazima Shaheen and Farzana Yasmin, for their enthusiasm, team spirit and hard work throughout the survey work, leaving early in the day and returning late in the evening in extremely hot weather. Many appreciative thanks also to Tahira Shamas, Nida Alvi, Qurratulain and Farzana Yasmin, for their excellent support in compiling all the data (sites information, analytical/laboratory test reports, pictures and the summarized stakeholder interviews, summaries of the earlier research carried out) in a most organized separate hard & soft files. Most of the analytical laboratory work was carried out at Cleaner Production Center, Sialkot and I am indebted to Mr Muhammad Atif & his team. I may not forget to express my gratitude to my colleague, Mr Ijlal Ashraf for designing the front title page and Mr Adnan Hassan, MIS, and his team, for their contributions to get this publication well on time.

I am deeply and gratefully indebted to Blacksmith Institute (presently Pure Earth) and Sustainable Development Policy Institute (SDPI), for the financial support, *Mr Bret Ericson*, program officer, BSI for the technical/training support and Engineer *Richard Fuller*, *President and Founder BSI* and Dr. *Abid Suleri*, Executive Director, SDPI, for their continued keen interest and all-time encouragement

At the twilight of my carrier, this publication is my humble gift on SDPI's 28th anniversary.

All praise belongs to Allah, Lord of all the worlds.

The AUTHOR

Islamabad-Pakistan

July 20, 2020

Chapter 1

1. INTRODUCTION

Pakistan environmental protection act defines hazardous substance and hazardous waste (PEPA, 1997) and based on the same a contaminated site may be described as an area which because of its hazardous contaminants (toxic, explosive, flammable, corrosive, radioactive or other characteristics) cause or is likely to cause, directly or in combination with others matters, an adverse environmental effect. Some other national environmental legislations in other countries, reflect somewhat similar broad perception. A contaminated land, according to UK environment protection act 1990 (UK EPA 1990) is, “Any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that - significant harm is being caused or there is a significant possibility of such harm being caused; or pollution of controlled waters is being, or is likely to be, caused”. “Harm” means harm to the health of living organisms or other interference with the ecological systems of which they form part and, in the case of man, includes harm to his property. (UK EPA 1990)). The availability, classification and distribution of contaminants and the hazards that present, differ significantly with location (ACE, 2013). Contaminants comprise of industrial solvents, metals, petroleum by-products, radiological substances, pesticides, leftover from manufacturing processes, along with determined naturally occurring materials such as asbestos. Land contamination has harmful impacts on animal and human wellbeing, on natural environment (such as air and water) as well as inhibits economic growth and the liveliness of local inhabitants (ACE, 2013).

All the products that pollute the soil are soil contaminants. The fundamental pollutants of the soil include biological agents, chemicals employed in agricultural practices, radioactive pollutants, urban wastes, and industrial wastes. Key contaminants of the polluted sites which are described, assessed and discussed, in details in the foregoing pages, are mostly metals – Lead (Pb), Copper (Cu), Nickel, Mercury (Hg), Arsenic (As) and Zinc (Zn).

1.1. Key contaminants studied at polluted sites, exposure and resulting adverse health effects

Key contaminants studied at polluted sites are briefly described below:

Lead (Pb) is a naturally occurring, bluish-gray, heavy and malleable metal without characteristic taste or smell, is rarely found naturally as a metal and occurs in the Earth's crust primarily as the mineral galena (PbS), and to a lesser extent as anglesite (PbSO₄) and cerussite (PbCO₃). It is a familiar metal in pipes, solder, weights, storage batteries, shot and ammunition, cover cables and devices to shield X-rays. The amount of lead used in gasoline, paints and ceramic products, caulking and pipe solder has been reduced in recent years to minimize lead's harmful effect on environment, people and animals. High levels of lead are found throughout the environment as the result of anthropogenic activities including burning fossil fuels, mining, and manufacturing. Sources of lead in dust and soil can include lead from weathering and chipping of lead-based paint from buildings, bridges, and other structures (ATSDR 2005; Currance et al 2007). Inhalation is the most common route of exposure among workers in lead industries. Ingestion is the other main route of exposure for the general population. Children are especially affected by sources of lead exposure including lead-based paint deteriorated into chips and lead dusts, pottery and drinking water. Many of lead's toxic properties are due to its ability to inhibit or mimic the action of calcium. The most sensitive target for lead toxicity is the developing nervous system and symptoms develop after exposure include muscle weakness with muscle and joint pain, paresthesia, depression, and headache. Anxiety, delirium, hallucinations, memory loss, insomnia, loss of consciousness, increased intracranial pressure, seizures, and encephalopathy may occur as a result of more severe acute or chronic exposure. Other targets of lead toxicity include kidney and cardiovascular systems in which anemia has been observed following severe acute intoxication particularly in children. Exposure to high amounts of lead may induce encephalopathy in children and adults anorexia, constipation, abdominal pain, and vomiting can occur after acute lead ingestion. Long-term exposure to lead can cause development of neurobehavioral alterations in children following prenatal (*in utero*) and/or postnatal exposure. Abortion and pre-term delivery in women and alterations in sperm and decreased fertility in men due to lead exposure has been associated in some epidemiological studies (Dart et al. 2004; HSDB 2007).

Arsenic (As), sometimes referred to as metallic arsenic, is another naturally occurring steel grey solid material that is widely distributed in the Earth's crust. About 90% of all arsenic produced is primarily used as a preservative for wood to make it resistant to rotting and decay. Some organic arsenic compounds may be used as pesticides or as additives in animal feed. Small

quantities of arsenic metal are used in alloys in products such as lead-acid batteries. Some arsenic compounds may also be found in semiconductors and light-emitting diodes. Arsenic attached to very small particles/particulates, may stay in the air for many days and travel long distances. Arsenic in soil transported by wind or in runoff may leach into the subsurface soil. (ATSDR 2005; HSDB 2007). One of the most toxic forms of arsenic is arsenic trioxide (Trisenox). Even 1 µg/kg of arsenic trioxide is a potentially fatal dose. Symptoms of arsenic trioxide systemic toxicity include burning of the lips, pharyngeal constriction, severe abdominal pain, nausea, vomiting, diarrhea, gastrointestinal hemorrhage, pulmonary edema, acute respiratory distress syndrome (ARDS), cerebral edema, tachycardia, dysrhythmias, encephalopathy, electrolyte abnormalities, hypovolemic shock, coma, and even death. Long term oral exposure to low levels of inorganic arsenic may cause dermal effects (such as hyperpigmentation and hyperkeratosis, corns and warts) and peripheral neuropathy in which sensory symptoms predominate early, with patients complaining of "pins and needles" or electrical shock like pains in the lower extremities. There may also be an increased risk of skin cancer, bladder cancer, and lung cancer. Polymorphous ventricular tachycardia, ventricular fibrillation, congestive heart failure, myalgia, weakness, muscular atrophy, and rhabdomyolysis, fatty infiltration of the liver, central necrosis, and cirrhosis may also occur (ATSDR 2005; HSDB 2007).

Cadmium (Cd) is a soft, silver-white metal that occurs in the earth's crust and is commonly associated with zinc, lead, and copper ores. It is refined and consumed for use in batteries, pigments, coatings and plating, stabilizers for plastics, nonferrous alloys and photovoltaic devices. Cadmium is released into the atmosphere both by natural and anthropogenic sources. Cadmium is emitted to soil, water and air by zinc, lead, copper & cadmium smelting operations, coal & oil-fired boiler, phosphate fertilizer manufacturing and municipal and sewage sludge incinerators. Generally, cadmium binds strongly to organic matter and be immobile in soil but taken up by plant life, eventually, entering the food supply, as it bioaccumulates at all levels of the food chain. The predominant route of exposure (about 5-50%) of the cadmium is inhalation through lungs. Only small amount of cadmium in food and water (about 1-10%) enters human body through the digestive tract. Most of the cadmium that enters human body goes to kidney and liver and can remain there for many years. The most sensitive targets of cadmium toxicity are the kidney and bone following oral exposure, kidney and lung following

inhalation exposure. Long term exposure effects observed in humans include renal tubular damage, glomerular damage, decreases in bone mineralization, increased risk of bone fractures, decreased lung function, and emphysema. Exposure to lower levels of cadmium for a long time can also cause bones to become fragile and break easily. Cadmium is a cumulative toxin and has a very long half time in the body, exposure to children even in low amounts may have long-term consequences (ATSDR 2005).

Chromium (Cr). The main species/forms of chromium are: chromium (0), chromium (III), and chromium (VI). Chromium is widely used in manufacturing processes to make various metal alloys such as stainless steel. Chromium can be found in many consumer products such as: wood treated with copper dichromate, leather tanned with chromic sulfate, stainless steel cookware, and metal-on-metal hip replacements. Chromium can be found in air, soil, and water after release from electroplating, leather tanning, textile production and chromium-based products industries. Electroplating, leather tanning and textile industries release large amounts of chromium to surface and sub-surface water. In general, chromium (VI) compounds are more toxic than chromium (III) compounds. The most sensitive targets of chromium (VI) are the respiratory (nasal, lung irritation and altered pulmonary function, following inhalation exposure), gastrointestinal (irritation, ulceration, stomach and small intestine lesions following oral exposure), hematological (microcytic, hypochromic anemia), and reproductive (decreased sperm count and epididymal damage) systems. The primary targets of chromium (III) compounds are the respiratory (following inhalation exposure) and immunological systems. Chromium allergic dermatitis is typically elicited by dermal contact in sensitized individuals. The concentrations causing respiratory problems in workers are at least 60 times higher than levels normally found in the environment. In workers, inhalation of chromium (VI) has been shown to cause lung cancer. In laboratory animals, chromium (VI) compounds have been shown to cause tumors to the stomach, intestinal tract, and lung (ATSDR 2005; HSDB 2007).

Mercury (Hg) exists in three forms, including metallic mercury (pure form also known as elemental mercury), inorganic mercury, and organic mercury. It is a shiny, silver-white, odorless and dense liquid that vaporizes easily at room temperature. In the chemical and mining industries, metallic mercury is used to produce chlorine gas and caustic soda and in extracting gold from ores. It is extensively used in electrical industry (e.g., alkaline batteries, electrical switches, fluorescent light bulbs/tubes), in dental amalgams and in

medical equipment (oral thermometers, barometers, sphygmomanometers) and wall thermostats for heating and cooling. Mercury salts are sometimes used in skin lightening creams and as antiseptic creams and ointments (Dart et al. 2004; HSDB 2007).

Approximately 80% of the mercury released from human activities is elemental mercury released to the air, primarily from coal-fired power plants, mining deposits/tailings/wastewater of ores that contain mercury, smelting and from solid waste incineration. Inorganic mercury is converted to methylmercury by some microorganisms (bacteria, phytoplankton in the ocean, and fungi) activity in water bodies or soil, accumulating it in the food chain, thus resulting in biomagnification at each successive trophic level.

The major route of exposure to elemental mercury is inhalation of mercury vapor. Children may be at higher risk for pulmonary toxicity and are more likely to develop respiratory failure. Respiratory symptoms may predominate (cough, sore throat, shortness of breath). Mercury may cause chemical pneumonitis, dyspnea, chest pain and dry cough, associated with fever, chills, and headache. These symptoms can progress to pulmonary edema, respiratory failure and death. Acute high-dose inhalation of elemental mercury vapor may result in abdominal cramps, metallic taste, nausea, diarrhea, ptyalism (heavy salivation), proteinuria, nephrotic syndrome, temporary tubular dysfunction, acute tubular necrosis, and oliguric renal failure. Visual disturbances, chronic nervous system damage, leading to neuropsychiatric disturbances and intention tremors may also occur. Mercury absorbed from vapor inhalation or dermal exposure can lead to acrodynia (or pink disease) with symptoms like abnormal redness of the skin, followed by peeling of skin on hands, nose, and soles of the feet. Mercury vapor can cross the blood-brain and placental barriers. (Dart et al. 2004; HSDB 2007).

Pesticides has been defined as any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm, during or otherwise interfering with the production, processing, storage, transport or marketing of food, agriculture commodities, wood & wood products, animal feed products or substances which may be administered to animals for the control of insects, arachnids or other pests in

or on their bodies. (FAO, 2007). On the basis of organism which is targeted by these pesticides, they are classified as insecticides, herbicides, fungicides, or fumigants. Pesticide residues remain for a very long time, cause serious toxic effects and disturb the ecological balance, by killing unharmed insects, animals, fishes and also modifies their genetics by creating resistance in them (pest) against these pesticides (Asghar et al.,2016). Pesticide exposure leads to increasing cases of Alzheimer& Parkinson disease and other neural defects like memory loss, disruption of neural coordination in the body. It can result in disruption, paralysis of other system of body (digestive and respiratory system), inhibition or over production of neurotransmitter and high or no response of receptor site to these neurotransmitters. Children and fetus during their developmental period are more vulnerable to these pesticides than adults because of weak and inactive immune system. The most harmful effect of pesticides for both adults and children are their carcinogenic effects. This exposure results in leukemia, bladder, clone, thyroid and brain cancer in individuals exposed to pesticides (Asghar et al., 2016).

Industrial emissions, discharged waste water/effluents are the well-established and reported point sources of releases of the above key pollutants into environmental segments (water, air & soil) as well human exposure to these chemicals through different pathways. Pakistan national environmental quality standards (NEQSs) for municipal and industrial releases (waste water/effluents), the permissible limits of selected pollutants in drinking water, irrigation water, soil and vegetables, and some selected metals on 2017 ATSDR priority list of toxic substances are given in Annex A/Table 1 – 4. In section 1.2. below earlier reported research carried out, mostly in Khyber Pakhtunkhwa, Punjab and Sindh provinces of Pakistan is briefly described. Chapter 2, 3 & 4 describe and discuss details of the initial site assessments (ISAs), carried out by the SDPI ISA team.

1.2. Earlier research on hazardous contaminants and polluted sites in Pakistan

Reviews and studies have been carried out and reported on the chemical contamination of surface and sub-surface water bodies and soil in the close vicinity of different sites in the country.

In a national report, Khan gave an account of main sources of hazardous wastes in the country and various problems associated with these wastes, including non-availability of reliable data. Providing details of a case study, Khan emphasized challenges and the needed efforts, in safe guarding and

disposing of just a few tons of outdated pesticides in Khyber Pakhtunkhwa (KPK) province (Khan 2001).

Studies on lead exposure and children has been reported by Khwaja and Shah et al. (2013). Blood lead levels were studied in school children, resulting from leaded petrol use and increasing road traffic (Khwaja 2003 & 2005) The reported level of Lead in air (in microgram/cubic centimeter) was 0.13-0.24 in Karachi (1980-81), 0.21-0.79 in Peshawar (1994-95), 0.89 – 7.85 in Lahore (1999-2000) and 0.71 – 10.00 in Rawalpindi (1999 – 2000). These results indicated a very alarming increase and high levels of lead in the ambient air at the sites and time of monitoring. The overall mean blood lead levels (in microgram per deciliter) in school children (n=900 boys & girls) below 15 years of age in three main cities were found to be 22.8 +/- 3.30, 19.00 +/- 6.48 and 2.30 +/- 0.19 (rural site). Recommendations of National environmental action plan (NEAP) with special reference to clean air and provision of clean fuel have been briefly described and discussed (Khwaja, 2003).

Ahad et al have monitored and reported the organochlorine pesticides in soil and water samples from selected obsolete pesticide stores in Pakistan. The soils of obsolete pesticide stores in Pakistan contained high levels of organochlorine pesticides that threatened human health, water resources and the environment. The soil samples mainly contained DDT, followed by lindane and heptachlor. Organochlorine pesticides in soil and water samples collected from obsolete pesticide stores are unevenly distributed. The contamination levels in NWFP (presently KPK), Punjab, and Sindh provinces were in the range of 247–9,157 mg kg⁻¹, 214–10,892 mg kg⁻¹, and 86–1,139 mg kg⁻¹, respectively (Ahad et al 2010). Plant transfer factors (PTF), daily intake of metals and health risk index (HRI) were calculated in the collected soil and vegetable samples (Khan et al 2010) which indicated that the leafy vegetables were highly enriched with heavy metals because of their capability to accumulate heavy metals from soil. PTF values were lower for all the selected heavy metals, except for cadmium (Cd). Furthermore, the HRI values were within the safe limit (01) except for lead (Pb). Health risks of metals through ingestion of vegetables were of great concern in the study area (Khan et al 2010)

Prasad and Khwaja reviewed, “Hazardous Waste in the Asian Pacific Region,” and concluded that the production and disposal of hazardous waste remain a substantial problem in many countries of the Asia Pacific region,

including Pakistan (Prasad and Khwaja 2011). The publication entitled, “Environmental Challenges and Constraints to Policy issues for Sustainable Industrial Development in Pakistan,” also provides a list of 39 polluted sites identified and investigated in 12 districts of KPK (5 sites), Sindh (7) and Punjab (25 sites) provinces of Pakistan as well as federal capital, Islamabad. (2). Among these 10 sites were considered priority sites for remediation action/s at the earliest. (Khwaja, 2012).

The study, “Human health risk from Heavy metal (via food crops consumption) with wastewater irrigation practices in Pakistan,” was designed to investigate the potential human health risks associated with consumption of food crops contaminated with toxic heavy metals (Khan et al 2013). Cadmium (Cd) in surface soils and Cd, lead (Pb) and chromium (Cr) in the irrigation water and food crops samples were above permissible limits. The accumulation factor (AF) was >1 for manganese (Mn) and Pb in different food crops. The Health Risk Index (HRI) was >1 for Pb in all food crops irrigated with wastewater and tube well water. HRI >1 was also recorded for Cd in all selected vegetables as well as for Mn in *Spinacia oleracea* irrigated with wastewater. All wastewater irrigated samples (soil and food crops) exhibited high relative contamination level as compared to samples irrigated with tube well water (Khan et al 2013)

A comprehensive review on “Current Status, Mechanism and Possible Sources of Arsenic (As) Contamination in Groundwater: A Global Perspective,” with Prominence of Pakistan Scenario has been reported by Ali et al. Globally, the biogeochemical processes mainly caused the dissolution of naturally occurring As into the groundwater sources. In Pakistan higher levels of sulphate (SO_4^{2-}), chloride (Cl^{-1}) and carbonate (CO_3^{2-}), high electrical conductivity (EC), high pH and abundance of As(V) were an indication of the oxidizing conditions prevailing in groundwater. The oxidative process appeared to be the dominant process of As release into Pakistan aquifer. Up to 2018, the 11 districts in Sindh and Punjab provinces had As contamination in groundwater beyond the WHO and National quality standard level. Tharparkar and Hyderabad along Indus River (Sindh) and Lahore-Kasur (Punjab) are well-known hotspots of natural geogenic As contamination in drinking water, extracted from aquifers (Ali et al 2018). The review also mentions numerous methods/processes in practice for As removal, including the direct removal of As by converting As (III) to As (V). According to Ali et al, the different efficient methods should be modified for pilot-scale application, to successfully remove As, by minimizing the

operating and preservation cost. Traditional processes of treatment such as lime softening, coagulation filtration, membrane filtration and iron (Fe) and manganese (Mn) oxidation could also be employed for the removal of As contaminations (Ali et al 2018).

Zia and Mehmood employing a quantitative method, recommend three main steps to be followed, (a) initial assessment of the site to be remediated, (ii) assessment of the exposure resulting from the site (survey including quantum of contaminants/contamination) and lastly (iii) remediation of the site. According to their findings, multiple factors were responsible for the land degradation in the country and the soil contaminants (at sites, values higher than WHO standards) were harmful to living beings. Lastly, the research findings confirm possible reduction in contamination of land/soil in the country, by employing control measures to minimize oil spills and industrial releases (Zia and Mehmood 2018).

In the foregoing pages, findings & recommendations of the reported research work are summarized, specifically carried out in Islamabad (Federal Capital), Khyber Pakhtunkhwa (1.2.1.), Punjab (1.2.2.) and Sindh (1.2.3.) provinces which was, searched through literature survey, mostly between 1990–2019.

1.2.1. KPK PROVINCE AND ISLAMABAD

A study was carried out by Saif et al for heavy metals accumulation in potentially contaminated soils of NWFP (presently KPK) Province. Forty samples were collected from soils, receiving industrial effluents as irrigation water and eight samples were collected from soils irrigated with tube-well waters. The results showed that the concentrations of heavy metals were significantly high in soils irrigated with effluents and because of the seasonal changes, the heavy metal concentrations levels tend to increase in summer, due to associated changes in temperature, pH, microbial activities and effluents input (Saif et al 2005).

Highest heavy metal concentrations in the agricultural soils of the selected southern districts of Khyber Pakhtunkhwa (KPK), were observed for Mn followed by Zn, Cr, Ni, and Cu by Rehman et al. The bioaccumulation of metals in vegetables was within the permissible risk limits, except for Cr which showed higher contamination in all the tested food crops. The trend of metal transfer factors for different vegetables was in the order of $Cu > Ni > Cr > Mn > Zn$. The calculated daily intake of metals (DIM) in adults and children through consumption of food crops was in the decreasing order of

Mn > Zn > Ni > Cr > Cu. The results of this study indicated that all the HRI values of the selected heavy metals were found within the safe limits (HRI < 1), with no significant health risk anticipated for the local consumers, through ingestion of these vegetables grown in the study area (Rehman et al, 2018).

A study to assess the heavy metal contamination of water, was conducted in residential areas along the Palosi Drain, Peshawar, KPK (Ilyas & Sarwar 2002) to assess heavy metal contamination. For this purpose, twenty water samples were analyzed for Cd, Pb, Ni, Cu, Fe, Zn and Mn contents. The results indicated that heavy metals such as Cd, Ni and Pb caused problems at some locations due to their elevated concentrations as compared to WHO's drinking water standards. The emission/release source could be the corrosion of plumbing and piping fixtures. It was concluded that sub-surface drinking water quality was generally good and the contaminated wastewater did not affect the water quality of shallow wells (Ilyas & Sarwar 2002).

Khan et al studied lead and cadmium contamination of different roadside soils and plants in Peshawar City, KPK province and observed that long-term exposure to traffic caused the contamination of the roadside soils and plants with Pb and Cd. All the data were analyzed using ANOVA analysis that showed a significant variation in Pb and Cd concentrations in the roadside soils and plants as compared to the reference site. Significant variation ($P \leq 0.01$) in concentrations of Pb and Cd in soil and plant samples along with primary, secondary and tertiary roads might be due to different traffic densities. The highest value (9.4) of metal accumulation index (MAI) was observed for Eucalyptus Camaldulensis. It was concluded that the contamination levels of soils and plants were in the order of primary road > secondary road > tertiary road > reference site (Khan et al 2011).

Khan et al and Yuosafzai et al studied the impact of industrial discharges on the Quality of Kabul River Water at Nowshera, KPK. Samples of effluents from different industries at Amangarh and the receiving Kabul River water were analyzed for various parameters. The results indicated localized pollution within half kilometer after the confluence point where the quality of the river was being deteriorated. Contaminations due to the heavy metals was not included in the two studies which recommended the installation of treatment plant/s for waste water discharges from the industries (Yousafzai et al 2008) and a recovery plant in paper/board mills to reduce the pollution due to black liquor (Khan et al 1990).

In NWFP (presently KPK), a study was also conducted in 2001/2002 during summer and winter seasons, to assess bioaccumulation of trace elements by different plant species grown on potentially contaminated soils (Huq 2005). A total of forty effluent irrigated plant samples were collected from Amangarh industrial area and Pirsabak, Nowshera, (NWFP/KPK). For comparison, four tube-well irrigated plant samples were also collected as reference. Samples were analyzed for Zn, Cu, Fe, Mn, Cd, Cr, Ni (Nickle) and Pb contents. The higher values were found in effluent irrigated plant tissues than tube-well irrigated plant tissues. The study recommended installation of treatment plants in the industrial area. (Huq 2005).

In view of the known toxicity, accumulative, persistent characteristics and adverse environmental and health impacts of DDT, an extensive survey of the soil was undertaken in and around a demolished DDT factory at Nowshera, NWFP, (presently KPK), to examine DDT levels of the contaminated soil (Khwaja 2008; Jan et al 2008; Younas et al 2009 & 2012). For this study, eighty-one samples were collected, in four opposite directions, within a half kilometer radius (as possible) from the old gate of the factory. Analytical data indicated that 90.91% of the soil samples studied were contaminated with DDT, with 66.6% of the samples indicating residual DDT levels higher than DDT minimum risk level (MRL) in soil ($0.05 \mu\text{g/g}$). Soil in the southeast direction appeared to be the most contaminated (average $6.70 \pm 1.25 \mu\text{g/g}$), showing $5.19 \mu\text{g/g}$ residual DDT in a soil samples, collected as far away as 520 m from the factory. Soil in the south direction also appeared highly contaminated, with an average DDT residual level of $7.16 \pm 1.70 \mu\text{g/g}$ between 65 and 390 m from the factory. For soil between the surface and at a depth of 0.60 m, the highest residual DDT level ($5.78 \pm 3.94 \mu\text{g/g}$) was observed in samples from the northwest direction, followed by samples from the west direction ($4.88 \pm 3.80 \mu\text{g/g}$). However, the analytical data indicated no immediate threat to underground water reservoirs (Jan et al 2008). The study report strongly recommended that the factory area must be recognized as a dangerous area and be closed for any human activities. Besides, a dire need to identify and implement processes for decontamination of DDT from the soil in and around the factory area (Khwaja 2008). Younas et al concluded from the findings of a follow up study that activated charcoal (AC) exhibits strong sorption of DDT in dry amended soil in laboratory conditions (Younas et al 2009 & 2012). To overcome the exposure and transport of the DDT, the site within the former DDT factory boundary wall was capped with

1.5 m of soil brought from a distant area on the outskirts of Nowshera (Khwaja 2012).

In Abbottabad, KPK, studies were carried out to analyze seasonal variation in the water quality of Salhad stream before and after the discharge of leachate from landfill situated at the bank of the stream (Maqbool et al 20011; 2012). Samples were collected from five different sites located along the stream. The study findings strongly suggested that landfill leachate had severe deleterious impact on the water quality of the stream. Heavy metals like Pb, Cd and Cu were released from the leachate into the stream which could likely affect the sustainability of the aquatic life. Integrated, multi-sector approaches and environmentally sound sustainable waste management were recommended, to deal with the contamination problem due to the accumulated heterogeneous (hospitals, commercial & municipal) waste at Salhad site/landfill to protect Salhad stream water quality and safeguarding public health residing in Salhad area (Maqbool et al 2011).

Muhammad et al investigated the soil and wild plants of the Pb–Zn sulfide bearing mineralized zone of Indian plate (IP) in the Pazang and Lahor sites, Kohistan region. Soil and plants were analyzed for some major cations including Fe, Mn, Pb, Zn, Cd, Cu, Cr, Ni & Co (cobalt) contents. Metal concentrations were used to quantify pollution contamination factors such as pollution load index (PLI) and plant bioaccumulation in soil and plants, developed in mineralized zones in the Lahor and Pazang sites and an unmineralized zone (reference sites) of the Besham area. Soil and plants of the mineralized zone and surrounding areas have higher heavy metal (HM) contamination ($P < 0.01$) as compared to the reference site, which can be attributed to the dispersion of metals from the mining activities. Furthermore, in mineralized zones, the Lahor site was more contaminated than the Pazang site. The high HM contamination around, could likely pose potential threats to the health of local communities, residing close to the mining sites, Kohistan region. The results also showed that plant species (*Plectranthus rugosus*, *Rumex hastatus*, *Fimbristylis dichotoma*, *Heteropogon conturtus* and *Myrsine Africana*) were the best HM accumulators (Muhammad et al 2011).

Health risks associated with heavy metals in the drinking water of Swat, has been studied and reported by Khan et al. Heavy metal contents were analyzed and compared with permissible limits set by PEPA and WHO. Among the studied heavy metals, concentration for Cr were highest followed by Mn > Ni

> Zn > Cd > Cu > Pb in the drinking water collected from both surface and groundwater sources in the study area. No health risk was observed in the area (HRI < 1) based on US EPA standards, while multi-fold higher concentrations of Cd, Cr, Ni, and Pb may pose potential health risks to the local residents. Multivariate and univariate statistical analyses showed that geologic and anthropogenic activities were the likely sources of water contamination with heavy metals in the study area (Khan et al 2013).

In agricultural soil of Swat district, heavy metal (HM) contamination was highest for Mn, followed by Ni > Cr > Cu > Zn > Cd which may significantly increase the concentrations of HMs in food crops cultivated in the area. In 95% fruit and 100% vegetables samples, among the metals studied, Cd concentration was found higher than the WHO limit (0.05 mg/kg). However, the health risk assessment revealed that there were no threat to public health in the area for most of the HMs except Cd, which showed a high level of HRI (Khan et al 2013).

For the analysis of heavy metals such as Zn, Cu, Cd, Pb, Cr and Mn in River Kabul at Sardaryab , KPK, water sampling was done at three locations of the River Kabul, at Shah Alam tributary (Amir et al 2017). The heavy metals analyzed were found to be in the range for Zn 1.14 - 1.86 ppm; Cu 1.03 - 1.22 ppm; Cd 0.12-0.89 ppm; Pb 0.08 - 1.08 ppm; Cr 0.02 - 0.12 ppm and Mn 0.03 - 0.29 ppm respectively. Pb, Cd and Cu contents in river water samples were found to be above, while the remaining heavy metals below the permissible limits (Amir et al 2017).

In Buner District, a study was conducted to investigate the presence of Cadmium (Cd) and Lead (Pb) in roadside soil and the cultivated vegetable Shalgham - Brassica Rapa (Rehman 2018). Soil and the vegetable samples were collected from primary, secondary, tertiary roadside fields and the control site. Comparison of the analytical data of Cd and Pb in the soils and vegetable samples (from the 3 road sites and control sites) showed significant variations. The study concluded that the studied samples of the vegetable Shalgham, taken from different roads side farms were contaminated with Pb and Cd which may pose health risk to local population in the area, due to the consumption of the same (Rehman 2018).

Islamabad

Hydro-chemical groundwater investigations were conducted in the twin cities of Islamabad and Rawalpindi to examine the contamination of the ground

water. Representative Ninety (90) sampling points, both open bore wells and tube wells, as well as Nallah Lei, were selected for collecting water samples (Sajjad et al 1998). After the quality assessment, it was concluded that the quality of groundwater in Islamabad/Rawalpindi, except in the central area, was good and fit for human consumption and other uses. The ground water in the central part of Rawalpindi i.e. cantonment area contained high amounts of Nitrate, chloride, and Sulfates was of poor quality and may not be used for drinking purposes. Heavy metals contamination of water was not part of this study (Sajjad 1998).

Malik et al carried out studies on heavy metal contamination of soils in Islamabad and Sialkot. (Malik et al 2010 & 2010). In Islamabad study, the transfer, accessibility and accumulation of metals from soil to roots and shoots were evaluated in terms of Bioaccumulation factor (BAF), Translocation factor (TF) and Bioaccumulation coefficient (BAC). Studied toxic metals were Pb, Cu, Zn, Co, Ni and Cr. Most species of plant accumulated higher concentration of Pb, Cu and Zn than the normal limits in shoots. Accumulation of Zn was relatively higher in grasses. Concentration of Cu was highest in shoots followed by Zn, Cr, Pb, Co and Ni. None of the plant species studied were recognized as hyper accumulator; however, based on BCFs, TFs, and BACs values, mostly species have the potential for phyto stabilization and phyto extraction (Malik et al 2010).

A study was done to analyze the concentrations of selected metals, including, Cd, Co, Cr, Cu, Fe, Ni, Pb and Zn (Zinc) in surface soils, to assess the status of urban soil pollution and to identify sources of contaminations (Malik et al 2010). Hierarchical Cluster Analysis (HACA) indicated, concentrations of Cd, Co, and Pb with traffic related activities and Cr, Cu, Ni and Zn either associated with automobiles activities or industrial pollution. Spatial distribution maps exhibited relatively higher concentrations of Cd, Co, Cu, Ni, Pb, Cr and Zn along traffic routes in the city and streams. The results highlighted concentrations of Cd, Ni, Cr, Zn, and Pb measured in urban soil exceeded the permissible limit of surface soils. Furthermore, identification of the origin and potential sources of soil heavy metals could be essential in order to assess the environmental risk caused by heavy metals in the study area (Malik et al 2010).

Iqbal and Shah also studied the distribution, correlation and risk assessment of selected metals in urban soils of Islamabad. The distribution and variation of the studied metals Cd, Co, Cr, Cu, Fe, Mn, Pb and Zn in soils, exhibited

the seasonal variations, while, multivariate analysis revealed significant anthropogenic pollution of metals in Islamabad urban soils samples. Geo-accumulation index, enrichment factor and contamination factor exhibited moderate to high contamination of few metals in the studied soil samples, during summer and winter. Degree of contamination was observed higher in the soils during winters (Iqbal and Shah 2011).

1.2.2. PUNJAB PROVINCE

Jabbar et al studied pesticide residues in cropland soils and shallow groundwater in Punjab. The soils appeared to be loaded with the pesticide residues - a constant threat to public health and the environment. The organic pesticides, however, are not of significant concern as groundwater contaminants from agricultural use because of their poor solubility in water and as these are retained strongly by the soils. The principal mechanism by which pesticides are transported from soil to groundwater seemed downward percolation of water containing dissolved pesticides which may in the first phase only relatively affect the shallow aquifers but this could simply be a function of time when the deeper aquifers may also be contaminated (Jabbar 1993).

Farooqi et al carried out a study to assess the sources of Arsenic (As) and Fluoride (F⁻) in highly contaminated soils causing groundwater contamination in Punjab. Over 100 soil samples were analyzed and the results showed that the alluvial sediments contained low levels of fluoride (F⁻) and the terrace soils contained high concentrations of soluble F⁻ (maximum, 16 mg/kg; mean, 4 mg/kg; pH 8.0). The presence of high levels of As in the surface soil implies the contribution of air pollutants due to coal combustion and the use of fertilizers. Intensive mineral weathering under oxidizing conditions produces highly alkaline water that dissolves F⁻ and As adsorbed on the soil, thus releasing it into the groundwater. Infiltration of water from the surface into the shallowest groundwater seemed major cause of the contaminated groundwater in the area, while the structure of the aquifer could be another cause of the contaminated water in the area (Farooqi et al 2009).

Waste water samples collected from the studied area in Faisalabad were analyzed in the laboratory for heavy metals and their concentrations were compared with the critical levels of the metals in the edible portion of the vegetables (Najam & Nawaz 2015). Results showed that all the samples of wastewater had concentrations of lead and cadmium above WHO safe limit.

The concentrations of all the heavy metals (lead, cadmium, nickel, and zinc) were found to be lower than the standard values in all studied samples of soil. Levels of heavy metals were higher in the surface soil layer as compared to those in the subsoil layer. The mean concentrations of lead and nickel were found to be higher than the safe limits in all the vegetables studied. It was concluded that the consumption of such contaminated vegetables, may causes bioaccumulation of heavy metals in the human body, resulting in adverse health impacts on local population. (Najam and Nawaz 2015).

Ghafoor et al examined the chemical composition of effluents from different industries of the Faisalabad city and the quality of effluents with respect to EC, sodium absorption ratio (SAR) and residual sodium carbonate (RSC) from the Ghee and chemicals Mills were observed to be worse, compared to those from textile units and cereal grain processing industries. The concentrations of Fe, Mn, Cu, Zn, Pb and Ni were well below the safe limits in the effluents from all the sources as well as in both main drains in the area. Relevant control measures/practices have been recommended to be adapted to manage the effluent irrigation hazards associated with high SAR & RSC, as such measures/practices could be enough to arrest the transport/spreading of the heavy metal toxicity, if any, with respect to the soil, crop and cattle health, being fed on the locally grown folder (Ghafoor 1994).

Assessment of the characteristics of waste water/effluents from seven industries in the city zone area of Faisalabad, including ghee, Ni-Cr plating, battery, and tannery, textile: dyeing unit (DU) and finishing Unit (FU) was carried out by Hanif et al (2005). Among others, environmental pollutants, analyzed quantitatively included, nickel, zinc, copper, iron. The findings revealed that effluents from the all the studied industries were causing severe toxic metal pollution. However, the pollutants levels were different for different industries and varied from industry to industry (Hanif et al 2005).

Another study carried out in Faisalabad, on heavy metals (Cd, Ni and Pb) contamination of soils, plants and waters was by Farid et al. Soil, plant and water samples were collected in the vicinity of Madina town, Faisalabad, following 4 × 4 Km grids. The results of the study showed the concentration of metals in soil samples ranged for Cd (0.00-0.111 ppm), Pb (0.87-8.97 ppm) and Ni (0.017-1.72 ppm) at 0-15 cm depth; while Cd (0.00-0.88 ppm), Pb (0.43-6.77 ppm) and Ni (0.055-0.852 ppm) at 15-30 cm respectively. Cd, Pb and Ni concentration in the plants ranged from 0.00-2.25 ppm 1.11-5.29 ppm and 1.51-4.96 respectively. Concentration of metal in the ground water

ranged from Cd (0.00-0.06 ppm), Pb (0.10-11.10 ppm) and Ni (0.03-0.05). The concentration Pb and Ni was below the permissible limits while concentration of Cd in waters and plants above the permissible limits. City waste effluents must be treated for the detoxification of metals before use in irrigation purposes for crops (Farid et al 2015)..

Qadir et al carried out a study, to find the spatiotemporal changes in water quality of Nullah Aik, tributary of the *Chenab River*, not very far from Faisalabad. Stream/Nullah water samples were collected at seven sampling sites on seasonal basis from September 2004 to April 2006 and were analyzed for 24 water quality parameters. Most significant parameters which contributed in spatiotemporal variations were assessed statistically which identified three different classes of sites: Relatively unimpaired, impaired and less impaired regions on the basis of similarity among different physicochemical characteristics and pollutant level among the sampling sites. Detrended fluctuation analyses (DFA) produced the best results for identification of main variables for temporal and spatial analysis and eight parameters (including Pb, Cr and Zn) that accounted 89.7% of total variations of spatial analysis. The results signified that parameters identified by statistical analyses were the cause for water quality changes (Qadir et al 2007).

Adeel et al studied the human health risk assessment and dietary intake of organochlorine pesticides (OCPs) through air, soil and food crops (wheat & rice) along two tributaries of river Chenab. Investigation included OCP levels, distribution profile and source apportionment in the cereal crops, air & soil samples, along with, hazardous effects on human health and dietary intake of OCPs through consumption of contaminated rice and wheat. Among studied OCP isomers, DDTs and HCHs were found pre-dominant in the examined samples. OCPs concentration ranged between 123 and 635 pg m⁻¹ for air and 365 ng g⁻¹, 2.72 and 36.6 ng g⁻¹, 0.55 and 15.2 ng g⁻¹ (dry weight) for, soil, rice and wheat samples, respectively. Estimated daily intake (EDI) of OCPs through rice and wheat was found 39 and 40 ng kg⁻¹ day⁻¹, respectively. The study strongly recommended that if the practice of wastewater irrigation and unplanned, indiscriminate pesticides dumping at sites continued, due to hazardous chemical exposure, the risk to public health and cattle would likely be more threatening in the study area (Adeel et al 2014).

Farooqi et al studied the toxic fluoride (F⁻) and arsenic (As) contaminated groundwater in the Lahore and Kasur districts, Punjab and their possible release source/s. Highly arsenic contaminated water is considered a serious problem in Pakistan, based on the monitoring program of groundwater quality. Five rainwater and 24 groundwater samples from three different depths were collected from Kasur & Lahore areas and analyzed for As & F⁻ contents. Shallow groundwater from 24 to 27 m depth contained high F⁻ (2.47 - 21.1 mg/L), while the groundwater samples from the deeper depth were free from fluoride contamination. All groundwater samples contained high As content (32 - 1900 mg/L), in excess of WHO drinking water standards. It appeared that pollutants originated, in part, from coal combustion at brick-kilns in the area and mobilized promotionally, by the alkaline nature (high pH) of the groundwater in the area. (Farooqi et al 2007).

The quality of wastewater was also evaluated from Rohi Nullah, Lahore, for one year (2008-2009) from those points where it was reported to be used for irrigation of crops on both sides of Nullah (Bashir et al 2014). Wastewater was examined for cadmium, nickel, chromium, zinc, manganese (Mn), cobalt and copper. The concentration of nickel, chromium, manganese and copper was above the FAO standards, while the concentration of cadmium, zinc and cobalt fell within FAO standards. Considering NEQS standards, the metals concentration was within national standards limits. Temporal variations were prominent in some parameters and mostly higher values were observed in summer and lower in winter season. There was accumulation of heavy metals in soils receiving wastewater for irrigation. The metal contents in soils follow the order Mn > Co > Zn > Cr > Ni > Cu > Cd. It was also observed that the concentration of all studied toxic metals in edible part of the vegetables was above the critical level (Bashir et al 2014).

The concentrations of total chromium (Cr) and its species - Cr (III) and Cr (VI), were assessed by Rafique et al., in soil, drinking water and effluents of tanneries, in/around ten tannery clusters of Sialkot District, Punjab. 120 samples, consisting 40 samples each of topsoil, drinking water, and composite wastewater, were collected from the selected tannery clusters. The concentration of total chromium, Cr (III), and Cr (VI) in wastewater, drinking water, and soil was found to be in range of (Cr) 16.12-36 83 mg/L, 1.0483-3.1824 mg/L. and 3.45-11.43 mg/kg; (Cr (III) 0.97-13 25 mg/L, 0-1 05. and 1.6-9.8 mg/kg, and Cr (VI) 69-28 ppm. 0.8-6 ppm, and 2-12 ppm, respectively. The concentrations of chromium contents were above the

Pakistan National Environmental Standard (NEQSs). It was found that pH above 6 leads to higher concentration of Cr (VI) in-the studied samples, due to oxidation behavior. The study recommended treatment of wastewater before being discharged from the tanning units (Rafique et al 2010).

Ullah et al also carried out a study in Sialkot which was designed to assess the quality of groundwater in relation to heavy metal pollution and its implication on human health. Water samples were collected from twenty-five localities. Twenty-two physiochemical parameters including Manganese (Mn), Zinc (Zn), Lead (Pb), Copper (Cu), Nickel (Ni), Iron (Fe) and Chromium (Cr) were examined for their contents, in the collected water samples. The results were compared with standard guidelines of WHO and Pakistan Standard Quality Control Authority (PSQCA) for groundwater quality. Cluster Analysis (CA) grouped all sites into four zones based on spatial similarities and dissimilarities of physiochemical properties. The results revealed that the groundwater quality of the studied localities/area could be considered of good, as it was highly turbid (57% of total localities/sites) with high level of Zn, and Pb which were above WHO and PSQCA permissible limits. Factor Analysis (FA) and Discriminant Analysis (DA) revealed significant variables including, Pb, Fe and Mn which caused variations in groundwater quality. The un-treated and indiscriminate disposal of the industrial & urban wastes and the use of chemicals in agriculture (fertilizers, herbicides and pesticides) were the primary causes of the groundwater contamination. The study highlighted the dire need to control heavy metals contamination of groundwater (Ullah et al 2009).

In Sialkot, well known for tanned leather/leather products production worldwide, a study was initiated by Qadir & Malik, to examine concentration of heavy metals (lead (Pb), cadmium (Cd), chromium (Cr), and copper (Cu)) in the liver, gills, kidneys and muscles of eight edible fish species (*Channa punctata*, *Cirrhinus reba*, *Labeo rohita*, *Heteropneustes fossilis*, *Mystus cavasius*, *Oreochromis niloticus*, *Puntius sophore*, and *Wallago attu*). The study was carried out in upstream and downstream zones of the Nullah Aik and Palkhu tributaries of the River Chenab, located in Sialkot District (Qadir & Malik 2011) The pattern of metal accumulation in studied organs was in the order Cr>Pb>Cu>Cd. Liver showed greater metal accumulation, followed by gills, kidneys, and muscles. Mean concentrations of Cd, Cr, and Cu were higher in pre-monsoon compared to post-monsoon season. Measured concentrations of Pb, Cd, and Cr in muscles of species such as *C. punctata*, *W. attu*, *L. rohita*, *P. sophore*, and *O. niloticus* were above permissible limits

of heavy metals for human consumption, indicating potential health risks to consumers of the same (Qadir & Malik, 2011).

Tannery-affected surface soils from 72 sampling sites from industrial area of Sialkot district, were collected and analyzed for nine physicochemical parameters, nine heavy metals, and four macro-nutrients (Ali et al 2015). The results showed that concentration of heavy metals followed the order: Cr<Fe<Ni<Mn<Cu<Zn<Co<Pb<Cd. Ecological risk index (ERI) showed high potential ecological risk associated with Cd and Cr with mean concentrations above respective average shale/background values. The results were useful for released heavy metals source/s identification, enrichment, risk assessment and management of tannery-affected soils and could contribute as reference/guidance to monitoring programs at regional levels (Ali et al 2015).

In another study carried out by Junaid et al in Sialkot industrial sector, showed the increasing heavy metal pollution especially in the blood, urine, and hair samples of the exposed workers and indoor dust samples. The heavy metals Cr, Ni, Cd, and Pb were identified as the main pollutants, posing the highest health risks and inducing the oxidative stress among the factory workers. Shivering/crusting, cutting, and stitching of leather were highlighted as the highest heavy metals contributing unit operations/factory sections, as indicated in the bio-matrices of the exposed workers through ingestion of the contaminated dust. Results also indicated that the level of Cr in indoor industrial dust was more than twice, compared to the background household dust. Superoxide dismutase (SOD) level in the blood samples expressed significant positive correlation with Cr and Ni. Total hazard quotients (HQs)/hazard index (HI) were >1, and Cr (VI) exhibited higher cancer risks than that of Cd in the exposed workers. The study concluded that the unsafe and unhygienic indoor environment, contaminated with industrial dust, made factory workers susceptible to high metal exposure which could cause adverse effects on their health (Junaid et al 2017).

Zahir et al carried out a study to examine the concentrations of arsenic (As), chromium (Cr) and lead (Pb) in drinking water of district ***Sahiwal***, Punjab. Water samples from tube-well, filter plant, hand pump and tap were collected from 20 different locations. The range of concentrations of As III, As total, Cr VI, Cr Total and Pb in all types of water samples were below detection limit (BDL) to 24.00 ppb; BDL to 25 ppb; 5 to 6 ppm, 5 to 6 ppm and 2 to 23 ppb, respectively. The levels of arsenic and lead were lower than Pakistan

NEQs while chromium was observed to be above NEQs in all the studied water samples (Zahir et al 2015).

Study was carried out to evaluate the impact of untreated urban and industrial effluents on water quality of *river Ravi* (Shafi et al 2018). Water samples were collected from 11 polluted and relatively unpolluted sites along the river during low flow season and analyzed for heavy metals contents and physico-chemical parameters. At several polluted sites of the river, manganese and lead contents were higher than permissible limits, for aquatic ecosystems. In the studied samples, the highest concentration of nickel, zinc, manganese, cadmium and lead was 20.0 µg/L, 70.ug/L, 190.0 µg/L, 2.0 µg/L and 72.0µg/L respectively. Findings revealed that river water at downstream sites of wastewater from the drains was not suitable to support fish and other aquatic lives (Shafi 2018).

A recent study at Sharaq Pur, *Sheikhupura* district, was carried out by Riaz et al (2019), to assess the magnitude and human health impacts of heavy metals (Cd, Cr and Ni) presence in drinking water. For the purpose, different water samples were collected from twenty different sites of the city. Health risk assessment through Chronic Daily Intake (CDI), oral exposure, health quotient, health of children and adults was assessed. Detailed chemical analyses results showed that Ni and Cd concentrations in drinking water were higher than the permissible limits of WHO and NEQs at most of the sampling sites of the study area. However, Cr content was found to be within acceptable limit. Health risk assessment determined the chronic impacts in order Cd>Ni>Cr. On the basis of these results and from the findings of the related survey conducted with the local population, it was concluded that the problem of contaminated drinking water was a serious threat to the health of the local population (Riaz et al 2019).

For *Rawalpindi* region, a study was conducted by Mushtaq & Khan, to evaluate the characteristics of effluents/waste water used for irrigation purpose and also to elucidate impacts on heavy metals contents in the soils of the study area (Mushtaq & Khan 2010). Results indicated that among others, Cadmium and Chromium contents were above the critical limits in almost all the effluent samples. Ni, Pb & Cu were high, respectively, in 14, 10 and 5 collected effluent samples, as compared to the critical limits. On the basis of research findings, it was concluded that the studied effluents/waste water samples, collected from different locations of Rawalpindi, were not good for irrigation and crops production (Mushtaq & Khan 2010)

Toxic metals contaminated land due to the use of discharged waste water/effluents from the tanneries, can be effectively remediated with the indigenous fast-growing halophyte *S. fruticose* (Bareen and Tahira 2011) The contaminated land, adjacent to Depalpur Road, ***Kasur***, was rendered infertile, due to long term effluent logging from the leather industry. The pot and field experiments were carried out simultaneously. Pot experiments were conducted using the same field soil in column pots with the leachate collection facility. EDTA treatment resulted greater solubility of Cr in the soil pores, containing water. An adequate doze of EDTA would not only mobilize Cr for plant uptake but would also minimize the risk of leaching (Bareen and Tahira 2011)

Afzal et al studied the assessment of Heavy Metal Contamination in Soil and Groundwater at Leather Industrial Area of Kasur. In the study area of Kasur, where untreated leather industry effluents had been discharged for a long time, soil and groundwater were found to be contaminated with alarmingly high concentrations of various heavy metals (Afzal et al 2014). Samples were collected and analyzed for Cr, Fe, Ni, Cd, Pb, Zn, Co, and Mn. The data revealed that soil and groundwater in the study area are highly contaminated with all tested heavy metals, in particular, chromium concentrations which varied from 0.82 to 2.25mg/L and 1970 to 2980mg/kg, in ground water and soil, respectively. The contamination in the study area, particularly with Cr, required an effective strategy for remediation of the soil and de-toxification of groundwater (Afzal et al 2014).

1.2.3. SINDH PROVINCE

Reduction of chromate by microorganisms isolated from metal contaminated sites of ***Karachi***, Sindh was studied and reported by Badar et al. Three bacterial strains, two identified as *Pseudomonas stutzeri* and one as a strain of cucurbit yellow vine disease bacterium, isolated from a foundry soil and a tannery, respectively, in Pakistan, were found to be resistant to up to 1 mM chromate and anaerobically reduced Cr (VI) up to 100 M. These isolates were compared to strains isolated from an uncontaminated coastal site in UK and designated as K2 (*Pseudomonas synxantha*) K3 (*Bacillus* sp.), and J3 (unidentified Gram-positive strain). Overall the isolates from the Cr contaminated sites did not remove more Cr (VI) than Cr-unstressed bacteria but their tolerance to Cr (VI) could be potentially useful for bioremediation (Badar et al 2000). Earlier other studies have also indicated that the two P.

stutzeri strains could bioaccumulate, the copper compound, cupric carbide (Cu_2C).

No categorical study has yet reported/discussed, the geochemical baseline concentrations of metals in the urban soil of Karachi. The main aim of the study entitled “Geochemical Baseline Determination and Pollution Assessment of Heavy Metals in Urban Soils of Karachi, Pakistan,” (Karim et al 2014) was initiated to assess the pollution status of the urban soil through various geochemical and geo-statistical methods. The estimated baseline concentrations of Pb, Cr, Cu, Zn and Fe were 56.2, 12.9, 36.3, 123.0 and 11.8 mg/kg soil, respectively. Soils of some locations of Karachi were found to be enriched, moderately to moderately high with Pb. Cr and Cu had very low to moderate and Zn had very low enrichment. The findings of the study suggested the need to develop proper management strategies to minimize the toxic exposure and threat to public health, associated with the heavy metal contaminated urban soil in close vicinity to the residential areas. (Karim et al 2014).

A study to determine the concentrations of particulate matter with an aerodynamic diameter $\leq 10\mu\text{m}$ (PM10) and air transmitted particulate trace metals was carried out in different areas of Karachi's ambient air, for a one year period: June 2011 to June 2012 (Hashmi et al 2017) Furthermore, the study also compared the levels of particulate matter and trace metals with the proposed limiting values ($65\mu\text{g}/\text{m}^3$ for PM10) of the U.S. Environmental Protection Agency (US EPA). Arithmetic means of $361.0\mu\text{g}/\text{m}^3$ was determined for PM10 in commercial areas, $275.0\mu\text{g}/\text{m}^3$ in residential areas, $438.0\mu\text{g}/\text{m}^3$ in industrial areas and $68.9\mu\text{g}/\text{m}^3$ in urban background areas of Karachi. The average concentrations of Pb observed in commercial zone $1.36\mu\text{g}/\text{m}^3$, in residential zone $1.0\mu\text{g}/\text{m}^3$, in industrial zone $1.46\mu\text{g}/\text{m}^3$ and in urban background zone $0.6\mu\text{g}/\text{m}^3$, whereas; Cd concentration in commercial zone $0.10\mu\text{g}/\text{m}^3$, in residential zone $0.02\mu\text{g}/\text{m}^3$, in industrial zone $0.25\mu\text{g}/\text{m}^3$ and in urban background zone $0.01\mu\text{g}/\text{m}^3$, respectively (Hashmi et al 2017).

In a recent study in Karachi, Sahar and Siddiqui investigated the eight heavy metals (Fe, Cu, Zn, Cr, Ni, Co, Pb, and Cd) occurrence, risk assessment in the sediment, sentinel crab (*Macrophthalmus depressus*) of the mangrove and the coastal environment, due to extensive industrialization and urbanization. The sediment of the selected sites was analyzed for physiochemical properties - grain size composition, organic matter, and heavy metals. The environmental health and eco-toxicological profile of the habitat was

determined through the enrichment factor (EF), adverse effect index (AEI) and potential ecological risk index (RI), which revealed high anthropogenic influences along the Karachi coast. All heavy metals in crab showed significant spatial differences ($p < 0.001$) and the strong correlation between the essential and non-essential metals. Sediment-biota accumulation factor (SBAF) suggested active bio-accumulation (>1.0) in crabs for all metals, except Cr. Pb accumulation in crabs showed a significant increase ($p < 0.05$) with lead exposure/lead content in the studied sediments, indicating the potential of crab as a bioindicator for Pb contamination in the environment. Principal component analysis (PCA) concluded that environmental factors like seawater temperature, salinity, sediment grain size and organic matter had a significant association with different metal accumulation in crabs. The study recommended that anthropogenic activities need to be initiated with prior environmentally sound planning to safeguard the ecological components (Sahar and Siddiqui 2019).

Uzma et al carried out a study on water quality in some selected areas of districts Mirpurkhas and Larkana. Research findings revealed arsenic content (average 2.04 ppb +/- low variation) below WHO maximum permissible limit in Mirpurkhas areas. However, in Larkana district, concentration of arsenic in studied water samples, was found in the range 0.40-20.02 ppb. 10% of the water samples of District Larkana exceeded the WHO guideline value (10ppb) for arsenic. It was inferred from the study data that w. r. t. arsenic contamination of water, district Larkana was some-what more problematic area, as compared to Mirpurkhas district (Uzma et al 2006).

Jakhrani et al carried out the determination of arsenic and other toxic metals in drinking water of Khairpur, Sindh. In water samples collected from hand pump and tube well, arsenic content was found in the range of 0.24 - 315.6 mg l^{-1} and 0.3512 - 0.5 mg l^{-1} respectively. Arsenic level was observed to be high compared to WHO standard in most of the studied water samples. Levels of Fe, Co, Cu, and Ni in water samples from hand pump water were found to be 0.004 mg l^{-1} , 0 - 230 mg l^{-1} , 0 - 556 mg l^{-1} and 0 - 700 mg l^{-1} respectively. In tube well water samples, the metal levels was found to be 0.005 - 1.62 mg l^{-1} , 4 - 110 mg l^{-1} , 0-50 mg l^{-1} , and 0 - 360 mg l^{-1} for Fe, Co, Cu, and Ni respectively. The study recommended some urgent action by the concerned authorities, towards water quality management, in view of, among others, the threat to public health, specially from arsenic contaminated water

use, in the study areas (district Khairpur) and elsewhere in the country (Jakhrani et al 2009).

In a study by Shahzad et al, a total of 30 wastewater samples (industrial waste, cattle colony waste and domestic waste) and seawater (in front of Rehri Goth), from five sites along Rehri Creek (Sindh) area were collected and analyzed for different parameters, including heavy metals (Cr, Cu, Pb, Ni, As and Zn) which revealed that the concentration of heavy metals along the Creek was higher than earlier reported analytical data for the same. The study report concluded that the continued releases & accumulation of toxic pollutants was considered to be the cause, for ecological imbalances and biodiversity losses in the area (Shahzad et al 2009).

Shah et al carried out a study to determine the lead (Pb) distributions in blood and prevalence of elevated Pb exposure among children, age ranged (5–10 years), residing near industrialized region of Hyderabad city, Sindh. The results showed that significantly higher proportion of children living in the vicinity of industrial area, had blood lead levels (BLLs) in the range of 15.4-35.6 µg/dL, and 8.51-16.7 µg/dL for those living in the non-industrial area. In both groups, the blood BLL was observed to be higher in boys as compared to girls of same age group, though the difference was not significant ($p=0.178$). Negative correlation was observed between BLLs and hemoglobin levels. Childhood Pb-poisoning has aroused public attention as a public health problem in the country (Shah et al 2013).

Study on organochlorine pesticides (OCPs) in surface soils from obsolete pesticide dumping sites in Hyderabad City, has been studied and reported by Alamdar et al. OCPs contamination levels in both matrices (soil & air) clearly showed, significant differences ($p < 0.05$) at the pesticide dumping ground from the rest of the sampling sites. The higher concentration of OCPs in air samples correlated past and present usage of these compounds, in the vicinity of soil sampling sites. Elevated concentrations of DDTs and HCHs at pesticide dumping ground and its surroundings, posed potential exposure risk to biological organisms, safety of agricultural products and public health. The lack of pollutants identification, hazardous sites monitoring, poor enforcement of environmental protection/pollution control laws by the relevant government agencies, incomplete/outdated inventories, inadequate technical capacities/capabilities as well as financial constraints, appeared to be the major hindrances, towards environmentally sound & safe management of these contaminated sites. The study report highlighted an urgent need for

the same, including risk assessment of hazardous waste dumping sites (Alamdar et al 2014).

A study by Sanjrani et al was done in Badin, Sindh which focused on physio-chemical assessment of water resources used for drinking purpose. Samples from ten different sites of Badin city were collected and physio-chemical parameters, including heavy metals were examined to assess water quality at the sampling sites. Water samples from the hand pumps in Laghari and Jamali Villages were found to be contaminated, showing metallic contents of studied water samples, exceeding the WHO standard limits. The study recommended development of a detailed plan to address drinking water quality in the area, for safeguarding health of the local communities (Sanjrani et al 2018).

From the above brief account of the reported research work carried out in Pakistan, the potential threats to environment and public health, resulting from hazardous contaminants at polluted sites is most evident. However, proper monitoring and evaluation at sites, to assess the extent of risk to the health of local population resulting from the exposure to such close-by sites, has been lacking.

1.3. Pure Earth (PE) /Former Blacksmith Institute (BSI) and Sustainable Development Policy Institute (SDPI) initial site assessment (ISA) of contaminated sites in Pakistan

Pure Earth (formerly known as “Blacksmith Institute”, New York, USA) and SDPI, under the Global Inventory Project (GIP), undertook and carried out initial site assessment (ISA) of already as well as newly identified contaminated sites in the country. The scope of the GIP was limited to sites in low- and middle-income countries, including Pakistan and where point source (single fixed location) toxic pollutants exceeded international standards and impacted ecosystem and public health (BSI 2010). Toxic pollution is considered the largest cause of death in low- and middle- income countries. According to Pure Earth, over 100 million people are estimated to be at risk from toxic pollution, at level above the international health standards (Pure Earth 2016).

ISA standardized document (Annex B), developed by Pure Earth, was employed at the investigated sites by the SDPI 2-3 members investigating team. A complete ISA document of an investigated site provided data such as

GPS coordinates, site description, description of the pollution source/s, the concentration of the main pollutants relative to international (or national standards), the pathway/s to human exposure and where possible, the estimated population at risk (BSI 2010). Water & soil samples collected at each site were analyzed at certified laboratories, for the selected toxic chemicals in the studied matrix (solid, semi-solid & liquid). Government officials/responsible parties (local, district, provincial and federal agencies/departments) and other relevant stake-holder opinions regarding the visited site/s were sought pre-, during or post site visits.

Employing the above referred ISA document, SDPI ISA team, carried out, for the “First” time, an assessment of **38 contaminated sites** in the country. The sites included and reported in this publication are ONLY those visited and assessed by the SDPI ISA team, in the presence and direct supervision/involvement of the author himself at the sites. These included sites in country 3 provinces Khyber Pakhtunkhwa (5 sites in/around 3 cities), Punjab (24 sites, in/around 8 cities), Sind (7 sites in/around 2 cities) and (2 sites in/around) Islamabad the Federal Capital (Annex C). Details of ISA of each of these visited and investigated sites, including brief site information/data, point pollution sources at/close-by the sites, laboratory reports of the collected samples of waste water/effluents, soil and drinking water at the site for chemical analyses/laboratory tests and information based on interviewed stakeholders at & off the visited sites, are described and discussed in the foregoing chapters 2, 3 &4.

Chapter 2

2. KHYBER PAKHTUNKHWA (KPK) & FEDERAL CAPITAL ISLAMABAD

Seven sites, 5 in KPK and 2 in/around Federal capital, Islamabad were visited by the 3-membered SDPI ISA team for the initial site assessment (ISA).

2.1. Khyber Pakhtunkhwa (KPK)

Earlier accessible published data/reports by several researchers, have indicated the presence of residual hazardous chemicals and the resulting chemical contamination of water sources & the surrounding soil, at the studied sites in KPK (section 1.2.1/KPK). In the present study, the visited 5 sites in KPK province were located in/around Abbottabad (2), Nowshera (1) and Peshawar (2) cities. Brief information about these cities/districts, given below, has been taken from the respective cities/district website and the same may be visited for updates/further details. As requested, the names & affiliations of some of the stakeholders interviewed (available with SDPI & on records) are not included here.

2.1.1. ABOTTABAD

The two sites visited in Abbottabad were at Salhad and Banda Ali Khan (in Abbottabad city).

2.1.1.1. Hazardous waste dumping site Salhad

Abbottabad is at a distance of 121 Kilometers from Islamabad via Hasan Abdal. It is 1220 meters above sea level, in a valley surrounded by pine forests. The city is bounded at all four sides by the Sarban hills. Neighboring districts are Mansehara to the north, Muzaffarabad to the east, Haripur to the west and Rawalpindi to the south. Abbottabad is the headquarter (capital) of Hazara Division and is divided into union councils, localities, towns, colonies and neighborhoods. According to the census held in 2017, the population of district Abbottabad was 1,332,912 (approximately 216,534 households). Because of having a large number of schools and training institutes, it was also referred as "The City of Schools".

The visited hazardous site (Latitude: 34.10896; Longitude: 73.16629) was located close to Salhad village (Figure 1.1), located in between Havalian (1

Km) and Abbottabad (3-4Km) and being on main road to Abbottabad city, was easy to access. A small beautiful village, surrounded by green hills and having natural streams & springs, over the years, turned into a big waste dumping site of industrial, municipal, commercial and medical wastes (heaps of waste, like small hills). The open dumping site, within an area of 5 hectares, has been active since 1986, with diversified wastes also from Abbottabad city (including 3 hospitals there) thrown at the site.. The waste kept burning at the site, with emission of smoke & likely hazardous fumes/toxic gases, almost all the time, day & night (Figure 1.1.), also taking the air contaminants to the city surroundings, subject to the likely change of wind direction towards the main city. The members of the SDPI ISA team felt like breathing smoke, rather fresh air in the all green surroundings of the site. The air had a foul odor which also made breathing difficult. The likely key air pollutants emitting from the waste burning at the site were dust, suspended particulate matter/carbon particles (PM 10 & others) and toxic gases, affecting public health of local population, residing in the surrounding areas, including Abbottabad.



Figure 1.1. The huge dumpsite is located at latitude 34.10896 and 73.16629 Longitude.



Figure 1.2 Waste pickers at Salhad dumpsite



Figure 1.3 Interview with local resident.

Waste pickers (Figure 1.2.) frequently visited the sites. Besides, at the site there was also a cluster of 16-20 temporary households, called “Sweepers Colony.” The space around the site appeared playground for the children from sweepers’ colony (more than 100 residents including children).

In monsoon season due to rain, the runs off from the residual burnt waste dumps (kept accumulating) would most likely be affecting the quality of soil, underground and surface water (natural spring, streams/Nari). The spring water was being used (throughout the year) by local residents for drinking purpose and the stream water for domestic purposes and irrigation, for the cultivated crops (food as well as cash crops) in the surrounding fertile agriculture land. Due to likely presence of chemical contaminants in water and the agricultural land being used by the local residents, through multiple exposure-paths, the health of population around the Salhad dumpsite area was at risk from possible air-borne and water-borne diseases.

“Approximately 30,000 kg waste was dumped on daily basis at the site, also known as filth depot” said the Tehsil Municipal Administration (TMA) worker while talking to SDPI ISA team in his office. A member of the sanitary staff (35 years old) informed that waste from vegetable markets (Sabzi Mandi) was also thrown at the Salhad dumping site. 2 local female residents informed to the team, “Local residents were facing skin, eyes allergy and kidney problems, due to use of drinking water in the area.”

Professor of environmental sciences & geology at the local university, Abbottabad was also of the view that the residual chemical contaminants in the waste at the dump site were affecting the quality of natural water sources in the area. During discussion with the visiting SDPI ISA team at his office, DG EPA, KPK, stressed, *“The continuous burning of medical waste at Salhad dumping site, was resulting into increased air pollution which was a serious threat to environment and public health, especially of the local, Havalian and Abbottabad residents.”*

2.1.1.2. Hazardous Site, Banda Ali Khan

The visited site (Figure 2.1) was in a residential area surrounded by green fields. A drain (about 20 meters deep & 5 kilometer in length), close to Medical Complex in Abbottabad city (Latitude: 34,18087; Longitude: 73.22207) which among others pollution sources (industrial estate, vehicle battery & vehicle services/repair industrial units in the area), also received large volume of medical complex waste & waste water (a combination of medical waste, industrial effluents & municipal/household waste) and

discharged directly into the nearby Banda Ali Khan stream (Figures 2.1 & 2.2.). Local residents used stream water for irrigation and household needs (estimated population 1,50,000).



Figure 2.1. The contaminated site is located at latitude 34.18087 and 73.22207 Longitude

Lead and other heavy metals at the waste site, seemed the likely contaminants to enter into the surrounding water streams, soil and air and a threat to public health among the local population via multiple exposure pathways. (Section: 1.1).



Figure 2.2. The contaminated site drain



Figure 2.3. Data recording at the site

A local male resident (55years old) informed the SDPI ISA team that the drain started from medical complex, went along its boundary wall and finally making its way to Mangal Katha, Tanol. Another local resident (female) staying at the near-by housing colony over five years, said, “The household garbage was also thrown into the drain by local residents and there was always unpleasant, foul smell around.”

Hospital & municipal wastes management had long been an issue of critical concern, both for the health sector and civic authorities in Abbottabad. None of these bodies had the resources, the facilities or expertise to ensure the environmentally sound waste management/disposal. However, the Provincial

government had taken some measures, including installation of an incinerator at the medical complex.

2.1.2. NOWSHERA

The sites visited in Nowshera was a demolished pesticide factory at Aman Gargh (in the outskirts of Nowshera city).

2.1.2.1. Demolished Pesticide Factory site, Aman Garh

Nowshera, one of the largest cities of KPK is located on Grand Trunk road (about 26 miles from Peshawa), along the banks of river Kabul. It is bounded on the east by district Attock (Punjab province), in the west and north-west districts of Peshawar and Charsadda, districts Mardan and Swabi in the north and Kohat district in the south (population: 1,518,540 (2017); households: 198,808). The rivers in the District are Indus and Kabul river. Climate is temperate. There are numerous streams in the area which are the only source of drinking water for many villages. There were big industrial units operating in Nowshera, including paper, cement, glass, tobacco, and others.

The visited site (Latitude:34.00640; Longitude: 71.93499), close to a DDT pesticide factory was established in 1963 at Aman Gharh (population about 236,800) to meet the country's pesticide needs but was closed/abandoned in 1994 due to ban on production and use of pesticide DDT in the country.



Figure 3.1 The contaminated site is located at latitude 34.0064 and 71.93499 Longitude



Figure 3.2 Data collection at Amman the site



Figure 3.3 SDPI ISA team with local stakeholders

During the first visit of the contaminated site (Figure 3.1.) by SDPI research team in 2003, DDT odor was still in the air, also felt by the local residents living near the abandoned factory. Detailed studies have been reported by Khwaja et al on the highly contaminated DDT contaminated soil, water & plants in/around the abandoned factory (Khwaja et al 2003, 2008 & 2012; Younas et al 2009, 2012). The contamination primarily resulted from DDT production in the factory that remained in operation for so many years. The main factory drain led to the Kabul River and nearby villages. As indicated by the reported studies both the soil and water in and around the factory area were still contaminated with DDT, despite the closure of the factory in 1994. Data described in SDPI reports indicated that 90.91% of the soil samples (# 90 within half kilometer square surrounding area) were contaminated with DDT and 66.6% of the samples indicating residual DDT levels higher than DDT minimum risk level in soil (Khwaja et al 2003, 2008 & 2012).

The contamination within the factory area posed threat to public health and the environment and had serious consequences to ecosystem functions, food safety, and other aspects of human health. Even in a very minute amount, DDT can have very harmful effects on human health (especially of children) and health of other organisms. Fetus and unborn babies are badly affected by absorption of the accumulated DDT in the fats of their parents' bodies (section 1.1.). Humans can come in contact with DDT through contaminated air, soil, water and food. Nearby factory open area continued to be center of daily youth sports activities and children's playground.

Local residents said, *"Bad odor of DDT was around for almost 24 hours and children playing in the contaminated area, could be hazardous for their health."* Nazim (administrator), Union Council (local government), Aman

Gargh, during discussion with SDPI ISA visiting team agreed that the hazardous site was a matter of great concerns and needed immediate attention. According to him, *“There were more than 2500 households in the immediate surroundings of the factory area and the residual pesticide (DDT) emanating from the demolished factory/contaminated soil, had been posing serious threats to the health of the local population, since long.”* Director General, EPA KPK reaffirmed the same and said, *“The factory was located in the residential area and the people were seriously exposed to it.”*

The site surrounding area/soil due to persistent hazardous nature of pesticide DDT (one of the persistent organic compounds – POPs) very likely would remain contaminated with the DDT pesticide for quite some time and therefore, it was strongly recommended that the land in and around the hazardous site (demolished factory area) must not be sold or put to any residential, commercial or sports activities, without an environmental impact assessment (EIA) and the approval of the same from KPK EPA.

2.1.3. PESHAWAR

The two sites visited in Peshawar were at back of Agriculture University and at Jamrud Road, near Peshawar University.

2.1.3.1. Industrial Drain at back of Agricultural University, Peshawar

The site was close to Hayatabad, in the outskirts of provincial capital, Peshawar, historically known as “Frontier Town.”(population 4,269,079 (2017); households: around 489, 843). The beautiful Peshawar valley lies at the entrance of the world famous, Khyber Pass and holds the key to the gate way of the South Asian subcontinent. Kabul river enters the district at Warsak and after flowing through Peshawar plain, is divided into several streams/channels, finally joins Indus river near Attock city. The Plain of Peshawar is very fertile and famous for agricultural crops. The climate of Peshawar district is extreme. Rainfall is received both in summer and winter. The main crops of the area are wheat, sugarcane, and tobacco. Hayatabad is a modern planned suburb on the southwestern fringe of Peshawar city. There are several schools, colleges, a national university, hospital, private clinics, public parks, shopping malls and offices.



Figure: 4.1. The contaminated site is located at latitude 34.01852 and 71.47694 Longitude

Hayatabad area was developed as a residential area in the late 1970s but later on, a separate part of it developed as an “Industrial Estate,” with many industries, including Pharmaceutical, Match factories, Paper & Board, Ghee mills, Soap, Steel mills, Glass, Marble and others. The Peshawar Development Authority (PDA) was responsible for maintenance and development of the township.



Figure 4.2. Waste water sampling at the site



Figure 4.3. Meeting with stakeholder

The contaminated site (Latitude 34.01852 and Longitude 71.47694) was a large drain, approximately 750 m² (Figures 4.1. & 4.2) and carried the discharged effluents/waste water from factories located in the Hayatabad industrial estate (HIE) areas. Industrial effluents drain has been reported to contain many toxic chemicals, affecting the quality of surface and sub-surface water resources in the area (Ilyas 2002; Yousafzai et al 2008 and Rehman 2018). Samples of waste water from 3 sampling points along the HIE drain were collected by the SDPI ISA team for chemical examination/laboratory tests. Findings of the analytical testing reports (ATRs) of the composite samples, indicated presence of cadmium (0.12 mg Cd/L) in the studied effluents/waste-water samples (EAL 8, 2010). The human population can come into contact with such toxic chemicals through

exposure pathways, such as water, air and soil and the health of the local population (around 15,000) in the area could be at risk (section 1.1.). Some of these health issues have been reported by the local residents, including skin infections/allergies, hair diseases, respiratory infections, gastritis and ulcer problems.

While talking to SDPI ISA visiting team at Peshawar University campus, Professor at Environment Sciences Department informed that the industries at HIE (Hayatabad industrial estate) disposed of their effluents/waste water and wastes into the drain, without realizing the gravity of the resulting situation. *“Due to the drain & its contaminants, local residents were badly exposed to water borne diseases including diarrhea, hepatitis B and C, malaria and goiter, besides, the bad odor emanating from the drain,”* he said. According to him, the effluents/waste water must be pre-treated before discharge at the point source/s of the respective industries.

DG, KPK EPA affirmed, *“The drain site was posing serious threat to all forms of life in the area, the un-pleasant odor from it, also causing inconvenience to the passers-by, its contaminants, affecting the quality of drinking and the local residents compelled to purchase and use bottled water to meet their drinking water needs.”* He further added that the presence of factories in/around the residential area, discharging chemicals containing effluents/waste water, without any treatment at the site, may continue to cause environmental pollution, affecting public health.

2.1.3.2. Depleted Pesticides Dump, Jamrud Road, Peshawar

The visited site (Figure 5.1) was a Chemical Pesticides Store of the Department of Plant Protection; Regional Plant Quarantine and Aerial Pesticides Control Office, Ministry of Food Agriculture and Livestock, located at Jamrud Road, one Km away from Hayatabad Town in a populous residential area. A Public School for boys (around 1200 students) & Governmental official residential area close by the site (about 5 hectares) and the historical Islamia College and Peshawar University campus were just across the Jamrud road (Latitude: 33,99726; Longitude: 71,46852).



Figure 5.1. The contaminated site is located at latitude 33, 99726 and 71.46852 Longitude

Thirty big size drums in a shipping container and 130 small size blue containers were there, in the open space, in front of the government office. Some of the drums, having dark-brown color amorphous semi-solid chemical wastes, were visibly cracked. These drums with depleted/ outdated pesticides were left over and un-managed for many years. Earlier, EPA in collaboration with some local and international stakeholders tried to manage all of this waste locally, by transporting a part of it, to UK for incineration in a high temperature incineration plant (Khan 2001).



Figure 5.2. Depleted pesticide sampling



Figure 5.3. Soil sampling at contaminated site

To collect the semi-solid soil material from the drum and carrying to SDPI office, Islamabad, for chemical analyses in a laboratory, was a bad experience for SDPI ISA team members, due to its most strong pungent and unbearable odor. A member of the team felt shock & dizziness, with his eyes beginning to water, within seconds, during the very brief period of collecting the residue samples from one of the drums (Figure 5.2.). The soil around the drums area appeared to have changed its color due to mixing of soil with the residual chemical contaminants (via the leachate) coming out of cracked blue drums. Samples of the depleted pesticide/s (from drum) and the contaminated soil

(Figure 5.3.) around the cracked drums, were collected but latter on the laboratory tests/chemical analyses was not considered worthwhile, by SDPI ISA team, in view of the decomposed nature of the residual depleted pesticides.

Besides soil, water sources in the site surroundings, a tube well about 40 meters away and the nearby canal, could have been also contaminated by infiltration & runoffs from the site area, during rainy season. Local population, especial students of the nearby college for boys, has a continuous, direct contact/exposure, in particular through air, during hot summer season, as extremely pungent fumes kept coming out of the depleted cracked chemical pesticides drums. Public health could also be at risk, from chemical contaminants in/around the site, via other exposure pathways such as water and soil (section 1.1.). During SDPI ISA visiting team interviews with the local residents, there were complaints of asthma, eye allergy, skin and respiratory infection. A local male resident (staying with his family) of the nearby official residential area at the site, talking to the visiting informed that his both kids suffered from asthma.

During interviews with SDPI ISA team, environmental sciences experts at Peshawar University & DG, KPK EPA also expressed serious concerns about the site and immediate need for the contaminated land remediation/control measures for the site. Deputy Director (Technical), Agricultural Extension Department during his interview with the visiting SDPI ISA team at his office said, *“The drums containing depleted pesticide/s (& the floor contaminated soil) were shifted from the designated pesticides stores to open space in front of the office, due to the leaking drum/s contents on the floors of the store as well as its spillage/spread all over the floor & around.. Each rainy season aggravated the site situation many folds as the semisolid chemical/s further leached down into the gravel and soil and the likely resulting contaminating of the underground water table. The bad odors remained always there in the surrounding area.”*

The above described site posed serious environmental and health impacts for the local population. Even if all the depleted pesticides have been removed from the site area and disposed of, due to the residual chemicals in soil, water & air, the site and its surrounding area required an immediate environmental impact assessment (EIA) study and in the light of the findings/recommendations of EIA, appropriate remediation/control measures

to be taken, to safe guard public health, especially of the so many students going to the nearby school, college and university in the area. .

2.2. Federal Capital Islamabad

The two sites visited in the outskirts of the federal capital, Islamabad were at Humak and Lehtrar.

2.2.1. Hazardous Site, Humak, Industrial Triangle.

Islamabad, the capital city of Pakistan, located 14 kms north east of Rawalpindi, Margalla Hills in north and north east, was planned and built in 1960. Due to Islamabad's proximity to Rawalpindi, the two are considered twin cities. Hot summers, monsoon rains and cold winters with sparse snowfall in the hills, almost summarize the climate of this area (Population: 2,001,579 (2017); households: 335,408). The Humak Industrial Triangle (HIT), about 12 Km from Islamabad along Kahuta Road, on the bank of Swan River, is the hub of many pharmaceuticals industries and some other industries, including tiles, electronics & automation, air conditioning, vaccines, foundries, central heating system and poultry farms. The visited site (Latitude: 33.54537; Longitude: 73.14163), around 750 square meter area, was an industrial drain in the vicinity of HIT (Figure 6.1.). The pungent, grey-white liquid waste flowing in the drain, was a mix of industrial wastes (including chemicals) from the nearby industries, discharged directly into the drain without any pretreatment. SDPI ISA visiting team collected samples of waste water from 3



Figure 6.1. The contaminated site was located at latitude 33, 54537 and 73.14163 Longitude

sampling points along the HIE drain for chemical examination/laboratory tests (Figure 6.2.). Findings of the analytical testing reports (ATRs) of the composite samples, indicated chemical oxygen demand (COD) 420, Zinc 0.37 and Manganese 0.22 mg/liter. Lead, Copper & Nickel were found to be

absent in the studied effluents/waste-water samples (NP&SL, 2009). According to some research studies described in the preceding pages (section 1.2.1/Islamabad), the underground water quality of some areas in and around Islamabad, has been affected because of these industrial effluents/waste water. Published data suggested the presence of toxic metals and other hazardous chemicals in the studied underground water and soil samples, taken from the surrounding areas of waste sites (Sajjad et al 1998; Malik et al 2010 & Iqbal and Shah 2011). The drinking water quality could be affected due to leaching of effluents into sub-surface water table. The human population can come into contact with these toxic chemicals through exposure pathways, such as water, air and soil, through contaminated water use (drinking, food, washing/bathing & domestic) and the health of the local population (around 1000) in and around the site area could be at risk (section 1.1.). Some of these health issues have been reported by the local residents, including skin infections/allergies and respiratory infections.



Figure 6.2:Waste water/effluents sampling at the contaminated site..

During an interview of the SDPI ISA visiting team with working Pharmacists at Pharmaceuticals industry, they claimed, “We worked according to the international operational procedures and incinerators had been installed, for sound disposal of discarded waste/packing material, cartons, blister and, leaflets. The left-over/broken glass (sample vials, injections, solution bottles) was crushed and collected by waste collectors. The team was informed that other wastes such as antibiotics, multi vitamins and cephalosporin were washed with tap water/acid/base and disposed of into sewerage open drains.

2.2.2. Khanna Dak Site, Lehtarar

Khanna Daak is a small town of Lehtarar, in the outskirts of Islamabad, the Federal Capital (FC). The site was a wetland of approximately 5 hectares, located in Khanna Daak (Latitude: 33.63594; Longitude: 73.12139). The estimated population around the site was around 45,000. This area was a dumping site of industrial, household and cattle waste - the main industries in the area were woodwork, ceramics, various service workshops, marble and pipe manufacturing. As Capital Development Authority (CDA) imposed restriction and banned cattle rearing in the FC Islamabad, the cattle farm holders (with their cattle) also moved in Lehtarar area, along the wetland, resulting in their cattle's wastes getting dumped at the waste site. Four samples each of waste water from different sampling points in the wetland area (Figure 7.2.) and drinking water (tube-well water supply) were collected by the SDPI ISA visiting team for chemical examination/laboratory tests.



Figure 7.1. The contaminated site is located at latitude 33, 63594 and 73.12139 Longitude

The analytical testing reports (ATRs) of the studied waste water/effluents and drinking water composite samples, indicated presence of cadmium, arsenic, copper, zinc, nickel and chromium contents, less than 1 part per billion (< 1 ppb). Chromium content in drinking water samples (0.6 ppb) was lower than the same (0.8 ppb) in the waste water/effluents samples (PCRWR2010).



Figure7.2 Sampling at contaminated site

The contaminated water of the wetland would likely leach into underground water affecting its quality. The human population could come into contact with these toxic chemicals through exposure pathways, such as water, air and soil and the health of the local population in the area could be at risk (section 1.1.). Some of these health issues, including water borne diseases, were reported by the local residents. Due to overflow from the wetland during the rainy season, the situation was worse in terms of increased incidents of water borne diseases. Most of the people use tube wells water for domestic & drinking purposes and due to its poor quality, the public health was at risk. SDPI ASI visiting team was informed that a few years ago, the water of the wetland was so clean that it was directly used for drinking purpose by local residents.

According to the parents, residing at Raja Shayan Town (close to the Khana Dak site), *“The main source of contamination was sewerage waste due to which during last fifteen to twenty years, the water taste had been changed, besides acquiring an unpleasant odor and change in its color (from transparent to pale yellow)”* They also informed SDPI ASI visiting team that skin infections were very common among the local children who bathed or were washed//given bath with water in the wetland area.

The local doctor in Khana Dak also confirmed during interview at his clinic in the town and also added, *“Water borne diseases including diarrhea,*

hepatitis B and C, malaria, stomach / intestinal infections and goiter were common among the local residents of Lehtrar.” He was also of the view that the contaminated water of the wetland had leached into under-ground water table and since majority of the people’s drinking water source was tube well water supply, the local population health was affected, as the basic common precautionary practice, like boiling water before its use was not followed by them.

The Chairman of Union Council, Tarlai Kalan, Khanna Dak, while talking with the SDPI ISA visiting team also confirmed, *“The major sources of contamination of wetland water were sewerage and cattle wastes.”*. During the team discussion with Director (EIA/Monitoring), Pakistan EPA, at his office in Islamabad, among others, he emphasized *“Awareness Raising” programs for relevant stakeholders and general public about contaminated sites, their likely hazardous exposure and the resulting health impacts, especially on children and the local population.*

Chapter 3

3. PUNJAB

In Punjab province, the initial site assessment (ISA) of twenty four (24) sites was carried out by the 3-members SDPI team. These included 7 sites in Faisalabad, 5 sites each in Sialkot & Multan, Kasur (3 sites), Sahiwal (2) and one site each in Lahore, Rawalpindi and Khanewal. Brief information about these districts has been taken from the respective district website and the same may be visited for any further details. Earlier published data by several researchers, has indicated the presence of Chromium, Sulfide, Phenol and other chemical contaminants in underground water, at some sampling points in/close to the tannery areas in Punjab (section 1.2.3/Punjab)). As requested, the names & affiliations of some of the stakeholders interviewed (available with SDPI and on records) are not included here.

3.1. FAISAL ABAD

In district Faisal Abad, seven sites were visited by SDPI ISA team. These were located at Nishat Abad, Millat town, Dagrahwa road, Samandri road, Lokey village, Bedian Wala and Khuryanwala.

3.1.1. Hazardous site Nishat Abad

District *Faisal Abad* (old name Lyallpur), used to be also known as Manchester of Pakistan, is bounded on the North by Jhang & Sheikhpura districts, on the East by Okara & Sahiwal districts, Toba Tek Singh & Sahiwal districts are in the south and on the West are Toba Tek Singh and Jhang districts. It has extreme climate, May to July and December to February are the hottest and coldest months, respectively. With 4 sub-divisions, the district is cotton- and wheat-growing area (population (2017) 7,874,790 with 1,225,413 households). Faisal Abad is an important transportation and commercial center, especially for grains, cloth, and ghee (clarified butter). Industries, among others, include textiles, pharmaceuticals, chemicals, fertilizer, bicycles, machinery, hosiery, flour, sugar, vegetable oil, and soap. There are numerous experimental farms, cattle-breeding stations, several colleges and a well-established reputed Agricultural University in Faisalabad. Nishat Abad hazardous site (also known as Chenab Drain), located in a residential colony, namely Nishat Abad (Husain Abad), was a big lagoon/drain, 2 – 3 Km in length (width about 200 meters) (Latitude:

31.45423; Longitude: 73.12043), towards Sheikhpura district (Figure 8.1). The site area was densely populated. The lagoon/drain was in between a railway track & the close by industrial units. Despite the site location right in front of a well reputed and prosperous textile unit, no efforts seemed to have been made with regard to installation of a waste treatment plant or shifting of the disposal site out of the residential area.



Figure 8.1: The open drain/lagoon site was located at latitude 31.45423 and 73.12043 longitude.

The blackish waste water/effluents of the drain/lagoon appeared to contain many colored pigments and chemicals released from more than ten textile and six other industrial units/Group of industries in the vicinity of the site.



Figure 8.2: Waste water sampling at site.

Figure 8.3: Stakeholder -SDPI ISA team-meeting.

Samples of Waste water/effluents and soil from around the site area were collected by the SDPI ISA team for chemical examination/laboratory tests (Figure 8.2). Analytical tests reports (ATRs) indicated total chromium 0.02 mg/lite, sulphide 2.07 mg/liter and lead 0.04 mg/liter, in the studied waste water/effluents samples. pH of the waste water/effluents samples was found to be 7.5. Presence of phenol, nickel and lead were not indicated in the waste water/effluents samples from Nishat Abad site. However, the soil samples

collected from the site showed cadmium 28.92 mg/Kg (CPC ATRs 2010). The site could be a source of environmental and health problems among local population residing in the area, due to chemical contaminants present in soil & effluents/waste water (released from the textiles & other industrial units) via drinking water path way. The most likely health impacts could be skin & eyes diseases, allergic reactions and water borne diseases (section 1.1.). The chemically contaminated waste water of lagoon/drain was spread over a large area of the open land around the site, also corroding and badly damaging the nearby railway track.

A drain cleaner, working with a chemicals producing industry at the site for more than 25 years, informed SDPI ISA team that he was suffering from poor health (eyes irritation & fever) which he thought was caused by toxic substances in waste water/effluents, released to the drain from the nearby industrial units in the site area. The Manager (also a chemical engineer) working in a commercial/business development organization, while talking to the team said, *“The agricultural land was about 10 Km from Chenab drain, waste of which as well as of other drains was finally discharged into Cheniot River.”* He also informed that the *unregistered small printing and dying units (using highly toxic chromate- based dyes) discharged waste water/ effluents into the sewerage system which was also affecting the quality of sub-surface water (having high total dissolved content), used by the local population for drinking and household needs.”* Executive Director of an NGO residing near Catholic Church, Faisal Abad, also confirmed that industrial waste water/effluents were discharged into the sewerage system. *“There was lack of proper waste discharge drainage system because of which not only the underground water quality was affected but the newly repaired roads in and around the site area were also getting damaged, despite repairing and maintenance from time to time.”* he added.

3.1.2. Hazardous site Gokhuwal, Millat Town

Gokhuwal site (Figure 9.1) was located close to the residential area namely Millat Town, with surrounding cattle breeding farms and a vast area of cultivated land. The active site (Latitude: 31.48140; longitude: 73.10491) was a big stagnant pond-like area, about two & a half hectares land, filled with



Figure 9.1: The large pond site was located at latitude 31.48140 and 73.10491 longitude.

large volume of waste water & chemical effluents, coming out of the nearby textile processing units. The pond water being used for many purposes in the area, including irrigation to meet the household cattle and poultry water need. Waste water samples from the pond and soil samples from around the pond and nearby agricultural fields were collected by the SDPI ISA team for chemical examination/laboratory tests (Figure 9.2). Analytical testing reports (ATRs), indicated 0.02 mg/liter total chromium, sulfide 0.49 mg/liter and lead 0.24 mg/liter in the studied waste water samples. pH was found to be 8.8. Phenols, nickel and cadmium contents were below the detection limits, in the collected samples from the site. However, in the studied soil samples, cadmium content was found to be 35.76 mg/Kgm. Like waste water samples from the same site, also in soil samples the presence of nickel was not indicated (CPC ATRs 2010). The health impacts of chromium, sulfide, lead & cadmium have already been discussed in the preceding pages (section 1.1.). The presence of the same toxic contaminants in the effluents/waste water discharged from the textile units, could also contaminate the underground water & dairy products



Figure 9.2: Soil sampling at site



Figure 9.3: Site data recording

(from livestock) and affecting the health of the local residents around the site. Although the site was located in a thickly populated residential area, no effort

seemed to have been made, with regard to the management of the local cattle farms waste or discharged waste water/effluents from the nearby industrial units.

According to the Secretary General, Pakistan Textile Exporter Association, Faisalabad, “The two sites, Industrial Estate and Khurian Wala, were hazardous because of the waste discharged from the industrial units in the area. Most of the dyes used in industrial processes were azo- and metal-based dyes. Initially, a drainage was built to reclaim waterlogged land but the same became full of colored industrial waste water and effluents which also contained the residual dyes employed in the printing process.” The Manager of a commercial/business development organization, in Faisalabad, while talking to the team commented, “The cottage industry in the area, discharged the industrial effluents (contaminated with chemicals) directly into the sewerage system, affecting the quality of underground water which was no more used for drinking and local residents were forced to purchase the water canes, from the market.”

3.1.3. Hazardous site, Dagra Road

The site (Figure 10.1), about 750 square meter and active at the time of the visit by SDPI ISA team, was in a residential area, surrounded by many home based textile units, close to Dagra wala road, Faisal Abad (Latitude: 31.39165; Longitude: 73.08041). The small scale textile units discharged the residual chemicals containing effluents/waste water through a sewerage pipe line which corroded over the time, due to extensive use of chemicals in the textile processing and their release.



Figure 10.1: The site was located at latitude 31.39165 and 73.08041 longitude.

Because of the over use of the corroded and broken pipe/drain for the released effluents/waste water from the textile units, not only the same were

getting mixed up with sewage waste but also mixing and contaminating drinking water supply line & underground water table, gradually, resulting in deteriorating the water quality to be unfit, sooner or later, for drinking or household water needs.



Figure 10.2: Sampling site



Figure 10.3: Site surrounding residential area

Besides, as the old drain overflowed, the contaminated waste water accumulated on the streets in/around the residential area (*Figure 10.3*), resulting in local population exposure to adverse health impacts due to the residual toxic chemicals in the effluents/waste water released from the textile units in the area.

Waste water/effluents, soil and drinking water grab samples, were collected by the SDPI ISA team, from around the site (*Figure 10.2*) and residential area, for chemical examination/laboratory tests. Analytical tests reports (ATRs) of composite samples, indicated contents of chromium total 2.86, sulfide 2.89, lead 1.01, cadmium 0.62, nickel 10.08 and phenols 0.09 mg/liter, in the studied waste water/effluents samples. pH of the waste water/effluents samples was found to be 7.6. The soil samples collected from the site showed cadmium and nickel 27.04 and 141.6 mg/Kg, respectively. The collected drinking water samples from Daganwa road site, showed pH 7.02, presence of chromium total (0.05 mg/liter) and lead (0.28 mg/liter). However, phenol, sulfide and cadmium contents were not present in the studied drinking water samples (CPC ATRs 2010). The exposure pathways and the resulting health impacts of these hazardous chemicals on the environment and local population around the site would be expected to be as described in section 1.1 and similar to such sites in other areas. Although this site was also located in thickly populated residential area, no effort seemed to have been made by any of the stakeholders, with regard to the management of waste water/discharged effluents at the site.

3.1.4. Hazardous site, Samandri Road

The site (Figure 11.1) was in the old Faisalabad residential area (estimated population 1500), known as Muhammadi Street, Samandri road and in the very close vicinity to the site (3.1.3), at Dagrahwa road (Latitude: 31.39165; Longitude 73.08041), described above. However, unlike Dagrahwa, the site was a large lagoon in about 1,000 square meter area, filled with effluents/waste water, discharged from the nearby industrial units (including textiles processing units). Waste water/effluents grab samples were collected by the SDPI ISA team, from around the site for chemical examination/laboratory tests. Analytical tests reports (ATRs) of composite samples, indicated chromium total 0.21, sulfide 0.37, lead 0.43, cadmium 0.04 and nickel 6.78mg/liter. pH of the waste water/effluents samples was found to be 7.3 but unlike Dagrahwa site, the presence of phenols was not indicated, in the studied waste water/effluents samples from the site at Samandri road (CPC ATRs 2010).



Figure 11.1: The site was located at Muhammadi street , in very close vicinity to the site (4.1.3)

A comparison of the studied selected pollutants contents of the two sites showed Dagrahwa site more polluted than Samandri site, having all parameters values much higher than the same for Samandri site. From time to time, the drained effluents contaminated with chemicals (a few identified from the ATRs findings above), overflowed on Muhammadi Street and into the nearby low-lying vacant plots in the surrounding area. Like Dagrahwa site, these were, most likely also mixing up and contaminating the underground water quality, used by the local population for drinking/household water needs. The exposure pathways and the resulting impacts of these identified toxic chemicals on public health/local population and the environment around the site (section 1.1), would be expected to be similar to those of Dagrahwa site but to a lesser extent, due to much lower

contents of the same chemicals, in released effluents/waste water from the respective nearby industrial units at the two sites.



Figure 11.2: Sampling site



Figure 11.3: Meeting with stakeholder

Two loom workers (age above 45 years) at textile processing units in the site area, informed the visiting SDPI ISA team, “ The industrial effluents were discharged into the sewerage system and the resulting water pollution was causing adverse health impacts on local residents, who were using the Raybay Canal (in the area) poor quality water for drinking purpose.” The same was also confirmed by a local shop-keeper. A local female resident (about 35 years old) and living in Mohammadi Street for eleven years, while expressing her views about the discharged effluents/waste water issue said, “The residents were living amid foul and irritating odor of these discharged effluents from the industrial units in the area and causing diseases like hepatitis and coughing among local residents.” Assistant Manager of Consumer Testing Services in Faisal Abad, talking to SDPI ISA team informed that mostly chemicals dyes such as metal based dyes (Nickel, Lead & Cadmium) as well as some azo dyes were used in the textile dyeing processes and released into the environment with the discharged effluents, from the textile processing units in the area.

3.1.5. Hazardous site, Jaranwala Road

The specific active site (Figure 12.1), a big lagoon (about 80 meters in length and 70 meters in breadth), was located along busy Jaranwala road, near Lokey village, Khuryanwala, Faisalabad (Latitude: 31.47179; Longitude : 73.30225). The site was surrounded by agricultural land and close to residential area (estimated population 12,00 and 250 households). More than 15 textiles processing and spinning industrial units were in the area, releasing waste water/effluents (contaminated with chemicals) into the lagoon which when overflowed spread the stagnant green-colored waste water mixed with

the effluents, into open land, close to the residential area and onto the surrounding agricultural land.



Figure 12.1: The site was located at latitude 31.47179 and 73.30225 longitude

Grab samples of waste water /effluents and soil samples, from around the site area, were collected by SDPI ISA team for chemical examination/laboratory tests (Figure 12.2). Analytical tests reports (ATRs) of the composite samples, indicated chromium total 0.08, sulfide 0.20, lead 0.18, cadmium 0.27 and nickel 4.08 mg/liter, in the studied waste water/effluents samples. pH of the collected lagoon waste water/effluents samples was found to be 8.3. Presence of phenol was not indicated in the waste water/effluents samples from Jaranwala road site. The collected and studied composite soil samples from the site, showed cadmium content 3.08 mg/kg, however, analytical results did not show the presence of nickel (CPC ATRs 2010).



Figure 12.2: Sampling at site



Figure 12.3: Data collection at site

The site could be a source of environmental and health problems for the local population residing in the area, due to the identified chemical contaminants present in the soil & lagoon effluents/waste water, discharged from the nearby textiles & other industrial units in the area. The most likely health impacts, due to chemical exposure via water pathway, could be skin & eyes diseases, allergic reactions and water borne diseases (section 1.1.). Local residents

informed the visiting SDPI ISA team that the chemically contaminated land around the site was no more fertile for agricultural production. Like many other tanning waste sites in the country, although Jaranwala site was also located in residential area and close by agriculture land, no efforts/initiatives seemed to have been made by any relevant stakeholders, with regard to environmentally safe management of the effluents/waste water, released from industrial units near the site area. According to Environment Officer, District Faisal Abad, the major diseases due to industrial contamination, among the local population around hazardous sites were Hepatitis, depression, stomach upsets, allergic reactions and skin problems. “The major barrier in combating the pollution problem was the lack of political willingness and priority,” he said. He also informed the SDPI ISA visiting team that EPA environmental laboratory was going to be functional soon, to support monitoring, evaluation and assessment of hazardous sites.

3.1.6. Hazardous site, Johal

Johal site (Figure 13), an open drain (also called Sittara drain), just beside one of the 3 factories in the area, was located near Jandear Kalan & Bedian Wala, along Lahore-Sheikhupura-Faisalabad road (Latitude: 31.53769; Longitude: 73.46854). The site (about 1000 square meter) with agricultural land all around, was approximately 2 Km away from a village, with about 100 household and estimated population around 1000. The drain contained unbearable foul smelling and chemicals containing dark colored effluents/waste water, discharged from the factories situated in the vicinity of the site. Most likely, it could be affecting the environment, agricultural land, livestock and health of the local population in the area.



Figure13: (a)The site was located at latitude 31.53769 & 73.46854 longitude (b) Soil sampling at site.

As one of the factories was located on the road side, the foul-smelling chemicals containing drain affected population on both sides of the road, the agricultural land and local residents as well as people passing by the site. Waste water/effluents and soil samples (grab) were collected by the SDPI ISA team from and around the drain site, for chemical examination and laboratory tests.



Figure 13: (c) Meeting with stakeholder

Analytical tests reports (ATRs) of the composite samples, indicated chromium total 0.10, sulfide 0.15, lead 0.30 and phenol 0.02 mg/liter. pH of the waste water/effluents samples was found to be 7.9. Presence of cadmium was not indicated, in the studied waste water/effluents samples from the site at Johal (CPC ATRs 2010).

However, the soil samples showed the presence of cadmium (8.44 mg/Kg) and nickel (10.08 mg/Kg).

The quality of the underground water in the area could be affected by the presence of these Chemicals in the waste water/effluents of the drain, causing risk to the health of the local residents, if water with sub-standard quality used for drinking, house hold and irrigation purposes (section 1.1.). Some of the local residents complained about having skin problems and allergies, caused by the use of contaminated water from the hand pumps. One of the local factory-worker (age 26 years) and resident of the nearby village shared with the SDPI

ISA team, about his personnel health problems such as eyes irritation and fever. “Since there was no health care facility in the area, he spent one tenth of his salary on his and his family (three dependents) health care,” he added.

3.1.7. Hazardous site, Mian Khuryanwala

The site (Figure 14.1) was also located along Lahore-Sheikhupura-Faisalabad road and called Mian Khuryanwala (/Khurrianwala). Some of the site (Latitude: 31.40895; Longitude: 73.08346) characteristics, were similar to hazardous site, Johal (3.1.6) described above.

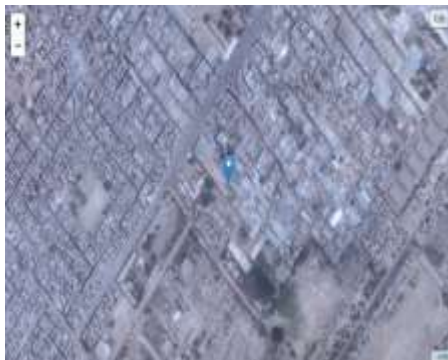


Figure14.1: The site was located at latitude 31.40895 and 73.08346 longitude

The drain, having chemicals containing effluent/waste water released from the nearby factories, ran through a residential area at one side and slum area on the other side of the drain. Like site 3.1.6, the drain contained dark colored foul smelling waste water/effluents, continuously discharged from the nearby industries in the area and posing threat to the environment and the quality of water sources around, especially the underground water, in the site area.



Figure14.2: Data recording at site



Figure14.3: Waste water sampling at site

Waste water/effluents samples (grab) were collected by the SDPI ISA team from the drain (Figure 14.3), for chemical examination/laboratory tests.

Analytical tests reports (ATRs) of the composite samples, indicated chromium total 0.09, sulfide 0.47, lead 0.45, phenol 0.05, nickel 0.39 and cadmium 0.18 mg/liter. pH of the waste water/effluents samples from Main Khuryanwala site was found to be 7.3(CPC ATRs 2010). At this site, content of some selected chemical pollutants (phenol, sulfide, lead & cadmium) were found to be higher than the same at Johal site (3.1.6.) which could be due to less chemically polluted waste water/effluents released from the factories into the drain at Johal (3.1.6.) site or the low pH (7.3) of waste water/effluents of Khuryanwala drain, compared to the pH (7.9) of the same at Johal drain. The environmental and health impacts of the studied chemical pollutants on the local population would expected to be same at both the sites (section 1.1) but somewhat higher at Main Khuryanwala site.

Local population (estimated 1200; households around 500) in the slum areas used water drawn out from bore well and also hand pumped out water, having some bad odor as well as taste (indicating its poor quality) for drinking, bathing and household needs. The local residents living (between 2 month and 30 years) in/around the site area (some in Ghosia Colony), were of the view that water was “Not Good for Drinking” and complained of having skin problems and allergies due to use of pumped out underground water .The children living in the slum crossed the polluted drain bare footed, to go from one side to the other and played around the drain, thereby risking likely chemical exposure and adverse health impacts, such as water borne diseases (section 1.1.).

SDPI ISA team had thorough discussion with two key stakeholders in the District Faisal Abad – Officer environment, Faisal Abad and Secretary General Pakistan Textile Exporter Association (PTEA). Their views are summarized below:

- Being major textile city in the country, excessive water pollution around due to textile processing industries (about 60 liters of wastewater/one-meter textile processing). At Jinnah Road, almost every household had Hozari and dyeing units and Maqbool Road area, initially outside of Faisalabad city, later on due to rapid expansion of the city, became part of the city.
- Need for immediate action to control the industrial pollution in Faisalabad, due to its resulting impacts on environmental and health of population (living close to the hazardous waste sites), among others (according to some reports), people hairs turning to gray at early age as well as increased rate of hair fall.

- Feasibility projects underway to overcome pollution in the city, looking at both the transport structure and Industrial units, for a decision either to shift the residential area or the industrial area. “Industrial City (M31C/Motorway 3) and “Value Added City” projects already initiated.
- Mandatory prior no objection certificate (NOC) for the factories from the government/EPA, for developing and maintaining environmentally sound drainage of wastewater/effluents/sewage system. *In the recent past*, the constructed industrial waste water/effluents drainage- Maqbool Road to Satiana Road, was not sustainable and the need to look for local solution instead of waiting for donor support.

Other suggestions/recommendations by them included strict enforcement of “Faisalabad City District Government by Laws 2007;” cooperation of the industry/factory owners with high political influence & backing; motivation towards active role (involvement and interest) of PTEA members and awareness raising program for textile management, workers and local residents around textile processing sites.

3.2. KHANEWAL

One site visited in Khanewal was located at Moosa Virk, Mian Channu

3.2.1. Hazardous site Moosa Virk

District *Khanewal* is bounded by Sahiwal and Vehari districts on its eastern side, Jhang and Toba Tek Singh in the north, Multan and Muzaffarabad on its west and Lodhran district in its south. According to census held in 2017, population of the district (area 4,349 square kms) was around 2,922,000 with approximately 466,390 households. It is famous for the production of agricultural products and it is an important market for farmers. District climate is hot and dry in summer and cold in winter.



Figure 18.1 The Lagoon site, Moosa Virk, was located at latitude 30.42439 and 72.29726 longitude.

The visited Moosa Virk hazardous site (Figure 18.1), in Mian Channu, Khanewal was about 96 Kms, from Multan City (Latitude: 30.42439; Longitude: 72.29726). The site, with an area of 1,000 m² was a big lagoon of effluents/waste water, discharged from the adjacent paper and card board mills. Grab samples of waste water of the lagoon, soil samples and drinking water samples, around the site were collected by the visiting SDPI ISA team for chemical examination/laboratory tests.



Figure 18.2 Stakeholders consultations at the cultivated land, nearby Moosa Virk site.

The analytical test reports (ATRs) of the composite samples, indicated presence of chromium (0.04 mg/liter) and lead (0.37 mg/liter) in waste water samples. In soil composite samples, chromium was below the detection limit (BDL) but a very high lead (450 mg/kg) and cadmium (14.1 mg/kg) contents were indicated. ATRs of drinking water samples showed presence of cyanide (0.01 mg/liter), much below the NEQs (CPC ATRs 2011). Health of the local residents (including > 2500 schools children of 2 schools each for boys & girls) in the area could be affected due to residual chemicals via air, soil and drinking water path ways (section 1.1.). Potential risk was also evident to the six fish breeding farms close by the site due to possible effluents overflow. The site was producing foul odor all around, from the lagoon as well as the waste from the adjacent paper and card board mills. Besides, the site due to lagoon standing water, seemed a most likely heaven for mosquitoes-breeding place. According to local residents, malaria was common around. Other reported health problems among the local population were anemia, kidney damage, reproductive affects and Gastro-intestinal disturbances (section 1.1).

A local resident (age 24 years), living at the site for more than 10 years, informed the visiting SDPI ISA team that the site continuously produced foul smell and there was no action taken despite the complaints by the local

residents. During, at site interviews by the SDPI ISA team, two more local residents talking to the team said, “Four papers mills in the area had similar operating processes and discharging the mills effluents/waste water into the lagoon.” The seemingly, most alarming SDPI ISA team’s observation/impression from the site was, the possible use of the polluted waste water/effluents discharged by the mills for irrigation, in the close-by agricultural land, cultivated with cotton crops at the time of the team’s visit (Figure 18.2). In view of the scattered polluting industrial units in Khanewal and other nearby places, an industrial zone was direly needed to be established and the waste water & effluents discharged from the industrial units to be pre-treated with an installed combined treatment plant, within the proposed industrial zone in the area.

3.3. KASUR

The three sites visited in district Kasur were located at Bangla Kamboyan, Maan village & Younis Nagar.

3.3.1. Hazardous site Bangla Kamboyan

Kasur (or Qasoor) District is about 55 kilometers south of Lahore. The district (area: around 3,894 square Kilometer; population (2017) 3,455,000 with about 526,200 households) is bounded by Lahore district in the north, east and south-east by India, on the south-west by Okara district and on the north-west by Sheikhpura district. Ravi and Sutlej rivers flow close by district Kasur. The district (with three Tehsils) has extreme climate. June & January are considered, the hottest and coldest months, respectively. There are 3 industrial centers (at Kasur city, Chunian & Pattoki) in the district, with over 1500 industrial units, mostly power looms, textile & leather/leather products.



Figure 19.1 The Open pond site was located at latitude 31.39067 and 74.33354 longitude.

Kasur is considered “Mother” of tanning industry in Pakistan and at the time of the visit by SDPI ISA team, there were around 350 small tanning units operating in Kasur district. The specific site (Figure 19.1), a big open pond, close to Kasur treatment plant, was located near village Bangla Kamboyan, Depalpur road (Latitude: 31.39067; Longitude: 74.33354). It was about 3 kilometer away from Kasur city and in the middle of agriculture fields (main cultivated crops wheat, maize and vegetables). A school and residential areas were close to the site. The pond received waste water and effluents from the tanneries in the area.

Grab soil samples from around the lagoon and nearby agricultural fields were collected by the SDPI ISA team for chemical examination/laboratory tests (Figures 19.1 & 19.2). Findings of the analytical testing reports (ATRs) of composite samples, indicated the presence of chromium (6.33 mg/kg) in the studied soil samples (CPC ATRs 2010). Health of the local residents (around 2000) & others was at risk due to chromium contaminated soil and food crops grown on the agricultural land around the site (section 1.1.). The reported health impacts were skin diseases, anemia, child birth problem and high abortion rate.



Figure 19.2 Soil sampling at site



Figure 19.3 Meeting with stakeholder

The Lady Health Visitor at Delivery Home (Committee Chowk, Nasim Hayat Road, Kasur) informed SDPI ISA team, “Most of the females coming to the DH for treatment were anemic, suffer malnourishment with complaints of abdominal discomfort, Hepatitis C and abnormal births.” During interview, the Project Director, Kasur Tannery Waste Management Agency (KTWMA) shared with the visiting SDPI ISA team, “Generally, the primary level tanning processes were done here and then the hides were sent to Sialkot, where value added products were made. Kasur tannery water management plant was established as pretreatment plant (with 18 lagoons, including 2 for sludge) and was functioning accordingly. It was not a complete treatment plant and he

emphasized immediate construction of the same.” He further revealed that the owners of the tanning units lived comfortably far away in big cities and were unaware, as well as least concerned about the pollution related environmental and public health problems, due to their tanneries at the site.

3.3.2. Hazardous site Maan village

The site (Figure 20.1) at Maan village was a large lagoon surrounded by agriculture land, about 4km away from Kasur Waste Water Treatment Plant (Latitude: 31.14235; Longitude:74.44112), in a residential area (population around 5600), a primary & a secondary school close by the site.



Figure 20.1 The Lagoon site, Maan village, was located at latitude 31.14235 and 74.44112 longitude.

The visiting SDPI ISA team also observed a huge dump of municipal waste near the site, filling the air with unbearable foul odor. The stagnant standing waste water and effluents (from the industrial units in the area) of the lagoon was not only a nuisance for the local residents but most likely also contaminating the underground water table and soil around. Waste water (grab) samples from the lagoon, soil samples (grab) from around the lagoon and nearby agricultural fields and grab drinking water samples from the residential area, were collected by the SDPI ISA team (Figures 20.1& 20.2) for chemical examination/laboratory tests. Analytical testing reports (ATRs) of the composite samples indicated 0.44 mg/liter chromium content in the studied waste water samples and 15.75 mg/Kgm chromium content in the studied soil samples. However, the analytical reports did not show presence of chromium in the composite samples of drinking water collected from Maan village site (CPC ATRs 2010). The water was drawn through tube wells and water hand pumps for irrigation, drinking and household use. The main crops grown on the nearby agricultural land were vegetables, maize and wheat.



Figure 20.2 Soil sampling at the site



Figure 20.3 Meeting with stakeholder at the site

The reported health issues among the local population were allergic reactions, skin diseases, water borne diseases, anemia, child birth problems/deaths, high abortion rate, underweight babies at birth and cancer/lung cancer (section 1.1.). A local land owner (residing in the area for the 20 years) during interview with SDPI ISA team informed, “*For the last 6-7 months, the taste of the tube well water was not good and not suitable to drink anymore.*” The local farmers complained of decreasing soil fertility over few years due to waste water/ effluents discharged from the tanneries and other industrial units in the area. Although the site was located in the populated residential area and despite numerous formal complaints by the elders of surrounding villages, no effort seemed to have been made, with regard to environmentally sound management of waste at the site.

3.3.3. Hazardous site Younis Nagar

The Younas Nagar site (Figure 21.1) was about 0.5 km away from Depalpur Road and in a residential area (population around 1500) adjacent to a school and farming land at one end (Latitude: 31.05573; Longitude: 74.48067).



Figure 21.1 Hazardous site Younas Nagar was located at latitude 31.05573 and 74.48067

longitude.

The huge amount of colored waste water/effluents discharged from tanneries, through/without pipes was gathered in low lying area of the site, close to the residential area. Grab samples of colored waste water at the site and soil samples from the land around the site, were collected by the SDPI ISA team for chemical examination/laboratory tests.



Figure: 21.2 Waste water/effluent sampling at site. Figure 21.3 Meeting with stakeholder site.

Analytical laboratory test reports (ATRs) of the composite samples did not show presence of chromium in the soil samples. However, 0.38 mg/liter chromium content was indicated in the collected waste water/effluents samples collected at the site (CPC ATRs 2010). Health of the local residents around the site area could likely be affected due to chemical contaminants (including chromium) via drinking water path way (section 1.1.).

In the preceding pages, the views expressed by stakeholders regarding hazardous sites (lagoons/ponds), formed due to waste water/effluents discharged from the tanning units, also may well be applied to this site. In addition talking to the SDPI ISA visiting team at his office , among others, the CEO Cleaner production Institute, Lahore suggested, *“Our industrial sector should follow national environment quality standards (NEQs) for waste water and effluents releases from the industrial units and with recycling, our industries should extract chemicals from industrial effluents/waste water and be reused in the same or other industries, to keep surrounding environment clean, minimize chemicals use/cost and , save raw material/resources .”*

3.4. LAHORE

SDPI ISA team visited one site, Rohi Nala, located at Kahna Kacha, Guja Mata Road, Lahore.

3.3.4. Hazardous site Rohi Nala

Lahore, historically about 2000 years old, is the second largest city in Pakistan, provincial capital of Punjab province and considered it's cultural & scholarly/academic center. Glimpses of Mughal Art and Culture are all around Lahore. The district (area 1,772 square Kms; population 11,126,285 (2017) with about 1,757,691 households) is bounded by Sheikhpura district in the north and west (the two districts separated by Ravi River), India (district Amritsar) on the east and Kasur district in the south. The district has extreme climate, with hottest (May, June, July) and coldest (December, January & February) months the visited site, Rohi Nala (Figure 22.1), close by a water tube well, was located 20 kilometers from Lahore city (Latitude: 31.39867; Longitude: 74.33353).



Figure 22.1 Rohi Nala site, is located at latitude 31.39867 and 74.33353 longitude.

The site was a large drain of about 5 hectare in area which passed through parts of the city with a diversified infrastructure around, including factories, residential localities/villages, commercial markets, and agricultural land. The effluents coming out of the factories at Guja Mata road were directly discharged through pipes in the Rohi Nala.

Grab samples of waste water of the Nala, and soil were collected by the SDPI ISA visiting team for chemical examination/laboratory tests. Findings of the analytical testing reports (ATRs) of the composite samples, indicated presence of chromium (0.06 mg/liter and Zinc (0.33 mg/liter) in the collected waste water samples at site. In soil samples chromium and Zinc contents were 29.75 and 1.75 mg/kg, respectively (CPC ATRs 2010). The water drawn from the drain was used for different purposes, including, on times, for irrigation as informed during an interview by SDPI ISA team with the local farmer family at the site. The cultivated crops on the land around the site were rice, fodder and sugar. The local population at the site (about 3500) was

exposed to chemical contaminants of the Nalah via multiple pathways such as surface & subsurface water and air (dust/particulates), resulting in water and air borne diseases among the residents around the site area (section 1.1.).

During interviews at site, local residents informed the visiting SDPI ISA team that among others, hair loss (mostly among male population) was common in the area. The CEO of a mineral water supplier company shared with the team, *“There was a garbage dump at the left side of the river Ravi which also continuously contaminated the river water, however, the local residents in the area were using the contaminated surface and sub-surf water for their multiple needs. The Head of a cleaner production (NEQSS), recycle any form of waste/s generated by their industrial units & the chemicals so recovered be reused in their as well as other industrial units.*



Figure 22.2 Meetings with stakeholder

organization, a renowned urban planner, was of the opinion that industrial sector should follow country national environmental quality standards SDPI ISA team also met DG, EPA Punjab, at EPA office in Lahore, who shared all the relevant details of the old legacy and presently, active chemically contaminated sites in as well as outskirts of Lahore. DG, EPA claimed that for many chemically contaminated sites in Lahore, *“The industry owners had made appropriate way out, regarding discharge of waste water/effluents from their respective industrial units, including control measures for reduced lagoon forming effluents/waste water discharge.”* DG further claimed that many earlier hazardous sites formed due to the discharged chemically contaminated industrial wastes, had been wiped out.

3.4. MULTAN

The four sites visited by SDPI ISA team in district Multan were located at Pir Shahwala, Basti Khair Shah, Rehmat Colony and Shah Town.

3.4.1. Hazardous site Pir Shah Wala

Multan, about 356 km from provincial capital Lahore and located in the southern part of the Punjab province, is considered more or less the geographic center of the country. It is bounded on the east by Lodhran district, on the north by Khanewal district, Bahawalpur district is in the south and Chenab river on the west. The Sutlej River separates Multan from Bahawalpur and the Chenab River from Muzaffar Garh. According to 2017 census population of the district (comprising 4 Tehsils) is 4,745,109 (around 760,858 households). The climate of the district is dry hot in summer and cold in winter. Multan is famous for its crops: wheat, cotton and sugar cane as well as mangoes, citrus, guavas and pomegranates. Pir Shah Wala site was located (close to a tub-well) at Basti Darkhana, Walwat village near Sher Shah.



Figure 23.1 Pir Shah Wala site, located at Latitude 30.98521 and Longitude: 71.32513

The site (Figure 23.1) a huge pond (Latitude: 30.98521; Longitude: 7132513) was about 20 Km away from main city Multan and contained the mixed effluents/waste water, discharged through a drain from the nearby industrial zone/estate. From the pond site, the polluted water made its way towards Chenab river through open drains (Figure 23.2). Foul, unbearable smell was all around the site as well as the surrounding residential area (population around 1500; also two schools one each for girls & boys).



Figure 23.2 Pond waste water outgoing open drain



Figure 23.3 At site meeting with local residents

Grab waste water samples from the pond, soil samples from around the pond and drinking water samples from the site/residential area were collected by the SDPI ISA team for chemical examination/laboratory tests (Figure 24.3). Analytical tests reports (ATRs) of composite samples, indicated 0.04 mg/liter chromium, 0.48 mg/liter lead and 0.03 ppm cyanide contents in the studied waste water samples. Soil samples showed lead 173.25 and sulfide 3.53 mg/Kgm sulfide and the drinking water samples collected from the Pir Shah Wala site, indicated chromium and lead contents 0.04 and 0.43 mg/liter respectively (CPC ATRs 2011).



Figure 23.4 Waste water & soil sampling at Pir Shah Wala site

The analytical data reported indicated contamination of soil & sub-surface water in/around the site area, due to the hazardous chemicals containing polluted effluent/waste water of the pond and exposure to the same could likely be, serious threat to the health of the local residents (section 1.1.). Among others, the reported health complaints included kidney damage, gastrointestinal, allergic skin problems, children's sore eyes and reproductive problems. According to the local residents, many animals had fallen into the pond and died due to swallowing of contaminated water. The visiting SDPI ISA team was informed that the nearby agricultural land was no more productive due to contaminated soil and underground water employed for irrigation.

During conversation with the SDPI ASI team, head of the family living in a house adjacent to the site (with their grand-parents and children) said, *“We had been suffering due to the unpleasant odor all around the pond and because of it, the quality of the underground water had also been affected and was no more fit for drinking or cooking (the drawn out sub-surface water in open turned slightly yellow after some time). The open pond was the breeding place for mosquitoes, so malaria was common and there was no dispensary around for the patients.”* Another resident from the nearby Jarwala village (living at

site for about 20 years) informed the visiting SDPI ISA team that the industrial units at the industrial zone/estate released waste water/effluents (with chemical contaminants, including pesticide waste) into the pond and had no waste treatment plant. They also confirmed that the place was heaven for mosquitoes and an all-time continuous source of foul odor.

The President Board of management Multan Industrial Estate (MIE), during discussion with the SDPI ISA team at his office shared, “A *concrete drain needed to be constructed and a formal proposal for the same had been submitted to the Government, however, MIE should also provide financial support for such construction work.*” He also emphasized that Pollution must be reduced & curbed at the source through pre-treatment of any industrial effluents/waste water before their release by the industrial units. “*Stakeholders at every stage should be involved in all decision-making process and the Corporate Social Responsibility was the best approach to address the environmental problems,*” he added further.

3.4.2. Hazardous site Basti Khair Shah

The visited site (Figure 24.1) was located at Basiti Khair Shah, Nawab Pur Road, Purrana Bhatta in the middle of a thickly populated area, mostly having inhabitants of middle and lower middle-income classes. Bhatta site (Latitude: 30.21677; Longitude: 71.46410) was a legacy site (in about 1,000 m² area), close by an abandoned tannery that has been shifted, some time back, to the Multan industrial estate/zone away from the city. It still had the leftover remains of tannery unit operations. The tannery effluent/waste water made way to a ditch that had turned into a big pond. Soil (Figure 24.2), waste



Figure 24.1 Basiti Khair Shah site , located at Latitude 30.21677 and Longitude: 71.46410

water and drinking water grab samples were collected at the site and the surrounding areas by the visiting SDPI ISA team for chemical examination/laboratory tests. Analytical laboratory test reports (ATRs) of the

composite samples, did not indicate the presence of chromium content in the studied soil and drinking water samples. However, the analytical findings showed 0.04 mg/liter total chromium content, in the studied waste water samples, collected from the site (CPC ATRs 2011). Health of the local residents around the site area could be affected via water pathway, due to chemical contaminants (section 1.1.). The legacy site could be a source of environmental and health problems among local population residing in the area. The vacant tannery space around the site, was used as playground by the children, part of which was also under consideration for sale, at cheaper rate for residential/commercial use.



Figure 24.2 Soil sampling at Basti Khair Shah site

Female local residents, while talking to the visiting SDPI ISA team at site said, “Local residents’ hairs color had faded due to the use of contaminated underground water for washing/bathing” and that stomach diseases were common among the local residents. According to District Environment Officer, Multan, so far, there was no proper way of disposal of discharged/released waste water, effluent and solid wastes from industrial units in the area. He was not supportive of the sale of the old legacy industrial sites for residential or any other purposes. He further added that a few such sites were available around, in the city after a ban on operating industrial units within the city areas and their shifting to outside the city, at Multan industrial zone/estate.

3.4.3. Hazardous site Rehmat Colony

Rehmat colony site (about 1000 m²) was another legacy site (Figure 25.1) in Multan, visited by SDPI ISA team, located near Baba Qamardin Shrine, close to a few non-operational and abandoned tanning units.

The site (Latitude: 30.21478; Longitude 71.46366) was situated in populated area and there were residential houses all around it (estimated population about 1500).



Figure 25.1 Rehmat colony site, located at Latitude 30.21478 and Longitude: 71.46366

The vacant vast area had almost changed to residential area. The area appeared full of contaminated soil with residual chemicals of effluents/waste water discharged in the open, when the old tanning units at the site were operational. Generally, Cattle grazed on the overgrown vegetation at the site. The pumped-out under-ground water was used, both for drinking and other household needs by the local population around the site area. The children (who used the vacated area as playground) and residents were at health risk (such as skin diseases, allergic reactions, cancer) due to the likely presence of hazardous chemicals in dust, soil & water (section 1.1.).



Figure 25.2 Soil sampling at the site



Figure 25.3 Meeting with stakeholder in Multan

Grab soil samples from around the site area and drinking water samples from the residential area were collected by the SDPI ISA team for chemical examination/laboratory tests. Analytical tests reports (ATRs) of the composite samples, indicated 0.04 mg/liter chromium in the collected drinking water samples, however, the analytical data did not show the presence of chromium in the soil samples collected from Rehmat colony site (CPC ATRs 2011).

Local female residents at the site (for more than 50 years) informed the SDPI, ISA team, “*The tannery units were closed more than five years ago and shifted to Multan Industrial Estate/Zone. Hides for tanning processes were brought from Kasur. There used to be unbearable odor all around when these units were in operation.*” Comments & suggestion of District Environment Officer, Multan and President Board of management Multan Industrial Estate (MIE) regarding such legacy sites have already been mentioned in the preceding pages (3.5.1 & 3.5.2).

3.4.4. Hazardous site Shah Town

Shah Town site (Figure 26.1) was about 10-12 Km from the main city of Multan, located at Sameej Abad, Hasan Abad (Latitude: 28.85434; Longitude: 71.52620). The site was close to a fertilizer factory which discharged waste water/effluents into 3 huge settling chambers/ponds, about 2000 sqm each. Once one lagoon was filled with waste water/effluents, with the passage of time the solid waste in dissolved/suspended form got settled, the water was then drained out. In the meantime, the next pond started receiving the effluent/waste discharged from the factory and under-went the same process which was going on for the last more than 30 years.



Figure 26.1 Shah Town site, located at Latitude 28.85434 and Longitude: 71.52620

In hot and windy conditions, the dust/particulates from the settled solid cakes dispersed all around and settled on plants, crops, nearby houses and created breathing discomfort among the local population (about 30,000; houses around 5000; one middle school for both boys & girls).

The waste water with chemical contaminants was also affecting the quality of the underground water which was considered by the local resident not suitable for drinking and irrigation.



Figure 26.2 Transporting of waste at the site



Figure 26.3 Waste/Soil sampling at Shah Town site.

Grab waste water samples from the pond (26.1), soil samples from around the pond waste area (26.3) and drinking water samples from the site/residential area were collected by the SDPI ISA team for chemical examination/laboratory tests. Analytical tests reports (ATRs) of the composite samples, indicated, 0.37 mg/liter fluoride, 0.04 mg/liter, chromium and 35 ppm ammonia contents in the studied waste water samples. Studied site soil samples showed fluoride 423 mg/Kgm (chromium and carbonate contents were not indicated) and the drinking water samples collected from the Shah Town site, showed sulfate and fluoride contents 120 and 0.04 mg/liter, respectively (CPC ATRs 2011). The pathways for human exposure to these chemical contaminants at the site, could be either of air, water soil, food, dermal contact and via inhalation and may likely cause dental fluorosis, allergic/hypersensitivity, kidney damage, cancer, brain and bone diseases (section 1.1.).



Figure 26.4 Meeting with stakeholders

During interview with the SDPI ISA team, a local resident (male 64 years old), living in the vicinity of this site for over 40 years said, *“The taste of the underground water in the area was bitter and not fit for drinking. Chemical (Calcium containg) dust was spread all around the site area and inside the*

houses, causing irritation of skin and problems resulting from its inhaling. The released of gas/es (ammonia) also caused irritation of the eyes and vomiting among the local residents.” Another local resident (also male, 37 years age) agreed that the underground water was not fit for drinking, that crops and Cattle health were badly affected due to pollution around, adding that the waste water was going in the sewerage system. The District environmental officer, Multan shared with the visiting SDPI ISA team, *“Many contaminated sites were posing hazards in Multan city. In 2004-2005 a case was put up against the Fertilizers manufacturing unit,, as the industrial unit was spreading air pollution and water pollution in the surrounding area, due to the Ammonia leakage from its Nitro-phosphate fertilizers plant.”* According to him the toxic ammonia mixed waste water was discharged trough a drain in the "Nou Bahaar Canal" at about 2 Km distance from the site. *“So far there was no proper way of disposal of waste water and solid waste,”* he further added.

However, in a meeting with the Director Operational, Fertilizer company and his technical staff at his office , the SDPI ISA team was informed that the plant was in operation since 1978 and the ammonia gas leakage incidence took place in 2008, as the gas was accidently released from flayer system but since then, the problem had been solved and in case the pressure of the gas increased, the gas would, rather burn away, adding, *“Besides, a cooling meter treatment for Nitro-phosphate (NP) plant was also in place, as well.”*

3.5. RAWALPINDI

The one site visited in Rawalpindi was Nullah Lai, close to Jawed colony, Liaqat Bagh.

3.5.1. Hazardous site Nullah Lai

Rawalpindi also known as Pindi, is a city in the Pothawar Plateau near Islamabad, the capital of Pakistan. It is located in the Punjab province, 275 km to the north-west of Lahore. Rawalpindi district is bounded on the north by Islamabad Capital Territory and Abbottabad & Haripur districts (of KPK province), on the west by Attock district, Chakwal and Jhelum districts in the south and on the east by river Jhelum The district has an area of 5,286 sq km with 6 tehsils and 170 Union councils (population 5,405,633 (2017) & 888,765 household. Rawalpindi has a hot summer and moderate winter. The visited Nullah Lai (or Leh) site (Figure 27.1) was near Jawed colony (population

around 65, 000/28 slums), Liaqat Bagh (Latitude: 33.60330; Longitude: 73.06597).



Figure 27.1 Nullah Lai site located at latitude 33.60330 and 73.06597 longitude.

Nullah Lai (length 45 km with maximum width more than 35 meters) has been polluted with the waste water/effluents, coming from all sources including factories and a large number of houses in the adjacent area/s. Several side drains (including from I-9 & I-10 industrial areas of Islamabad) with all the incoming contaminants were connected to it.



Figure 27.2 Water sampling at Nullah Lai site



Figure 27.3 Visiting team meeting with stakeholders

Nullah Lait flowed through the city center all along, finally down to the River Soan in the outskirts of Rawalpindi.

Grab samples of waste water from 4 sampling points at the site were collected by visiting SDPI ISA team (Figure 27.2) for chemical analyses/laboratory tests. Analytical test reports of the composite samples indicated pH 7.1. and Lead, Zinc & Cadmium contents were found below the permissible limits (NEQSS) but a high chemical oxygen demand (COD = 390 mg/liter) of the studied waste water samples at Nullah Lai site (NP&SL 2009). Nullah Lei water quality was no more considered adequate for domestic use, even for washing of clothes. Due to polluted water of Nullah

Lai & its overflows, the contamination of the surface and sub-surface water bodies in the site area/s, most likely could also be contaminated. At the site, SDPI ISA team was informed by local residents that during heavy monsoon season, the Nullah Lai always overflowed, partly immersing most of the makeshift settlements (Kachi Abadis in around 28 slums) at the two sides of the Nullah. The already contaminated waste water, also further polluted with the wastes dumped around the sites, entered into the houses, affecting health of the households in and around the site areas.

During interview, two local residents informed the visiting team, *“Local population of the site area were badly facing the pollution problem and adversely affected by it. The open sewerage system spread bad odor, unhygienic conditions and loss to aesthetic values. Lack of proper sewerage network, sewage disposal and treatment had worsened conditions, especially for very poor people in slums/kachi abadi, living close to the nullah.”* Two members of the paramedical staff of the close by Municipal Medical Center informed SDPI ISA team about visits to MM Center by local patients with complaints of stomach aches, vomiting, allergies & skin itching diseases. While talking to SDPI ISA team, the Executive District Officer, Rawalpindi said, *“Government was focusing on widening the Nallah and removal of excessive silt through a designated project, as well as construction of small bridges for the local population/ passersby over the nallah and promotion/availability of containers/bins for solid wastes, to avoid dumping/throwing of trash/wastes into the nallah”* which was also confirmed by the Zila Nazim, adding the referred project was in progress, during his interview with the team at his office near Kachari in Rawalpindi.

3.6. SAHIWAL

The two sites visited in Sahiwal district were Rajpura (near Lower Bari Doab Canal) and Tannary waste site, Harappa.

3.6.1. Rajpura Hazardous site

Sahiwal district, originally known as Gugera (after the name of a small village on the left bank of Ravi River), is bordered by the Faisalabad and Toba Tek Singh districts to the north, Okara in the east, districts of Pakpattan and Vehari to the south and Khanewal to the west. The district (area: 3,201 square meter; population 2,517,500 (2017) with about 392,500 houses) lies between the river Ravi and Sukh Bias Nala. Sahiwal has extreme climate, green and fertile land, with a large forests cover.



Figure 28.1 Rajpura site located at latitude 30.65200 and 73.09412 longitude.

Industries in the district, among others, are mostly cotton, textile, leather, tanning and food processing units. Rajpura site (30.65200 Latitude; 73.09412 Longitude), also known as Melta Mela (Figure 28.1) was a big lagoon in about 5 hectares area, at the back of the tannery units (in operation since more than 35 years). A few of the tannery units were shifted to Khanpur. The site was in one of the most populated residential areas of Sahiwal city. Effluents/waste water of the tannery units were discharged into the lagoon. There were about 250-300 households (Majeed Colony) and two children schools (for girls and boys) close to the site. The agricultural farmland was used for cultivation of three main crops wheat, maize and cotton, Lower Bari Doab canal, the main source of irrigation water was close by the site.



Figure 28.2 Meeting with local resident



Figure 28.3 Sampling at the site.

Grab samples of waste water of the lagoon and soil around it were collected by the SDPI ISA visiting team (Figure 28.3) for chemical examination/laboratory tests. Findings of the analytical testing reports (ATRs) of composite waste water samples, indicated presence of chromium (0.04 mg/liter and phenol (0.01 mg/liter) and the sulfide content in soil was found to be 1.74 mg/kgm (CPC ATRs 2011). Local residents at the site (population around 1600) were exposed to chemical contaminants of the

lagoon via multiple pathways (surface & subsurface water and dust/particulates in air), resulting in water and air borne diseases, including skin diseases and allergic reactions (section 1.1.). There was no health facility in the area. According to District Environment Officer, Sahiwal, “*The tanneries and other industrial units were serious environmental and health hazards for the people living around the site*” He strongly supported the development of an industrial zone along with an effluent/waste water combined treatment plant, in the district..

3.6.2. Harappa Tannery Waste site

Harappa waste site (Latitude: 30.65216; Longitude: 73.093457) was located near Harappa bypass in the outskirts of Sahiwal (Figure 29.1). The site (about 1000 square meters) was close to a tannery that in operation seasonally.



Figure 29.1 Harappa site located at latitude 30.65216 and 73.09357 longitude.

Waste water/effluents of the tannery were discharged on the empty open area behind the tanning factory. The assessed site was surrounded by agricultural land. Bhudd canal passed nearby. On times, the waste water/effluents of tannery was used for irrigation purposes to the nearby cultivated lands and the surrounding cultivated bamboo trees. The soil and quality of surface & sub-surface water in the area were most likely expected to be affected by the chemical contaminants present in the discharged wastewater/effluents from the factory. Grab samples of the waste water/effluents and soil around the site were collected by the visiting SDPI ISA team for chemical examination/laboratory tests (Figure 29.2).

Analytical test reports (ATRs) of the composite samples, indicated presence of sulfide (1.00 mg/K gm.) in the studied soil samples. Phenol and chromium contents in the waste water/effluents samples were found to be 0.02 mg/liter and 0.04 mg/liter, respectively (CPC ATRs 2011).



Figure 29.2 Water sampling at the site



Figure 29.3 Meeting with local family at the site

The health of the local population (around 36, 000; households more than 1200) was at risk from the hazardous chemical contaminants present in the waste releases from the factory (section 1.1.) As informed by the local residents there was no health facility around.

Local farmers (husband & wife) talking to the visiting SDPI ISA team at site informed that many tanneries operated in the area but most of the units were shifted to different areas in Khanpur district. *“However, the soil around the site could still be contaminated by the chemical toxins present in the wastewater/effluents released by the nearby tanneries in the open areas,” they said.* District Environment Officer, Sahiwal, emphasized *“carrying out environmental impact assessment (EIA) of all tanneries operating in the district”* and as also mentioned under 3.7.1., the development of an industrial zone as well as a combined effluents/waste water treatment plant. He also lamented inadequate qualified staff and lack of vehicle (for sites visit) and a well-equipped laboratory facilities around.

3.7. SIALKOT

Five sites were visited by SDPI ISA team in Sialkot, located at Modair Pur, Muzaffar Pur, Sahu Wala, Malik-e-Kalan and Rohail Garah.

3.7.1. Modair Pur Hazardous site

Sialkot district, the 13th most populated metropolitan area in Pakistan is in the north-east of Punjab province. Located at the foot of the Kashmir hills near the Chenab River, Sialkot is about 125 km from Punjab province capital, Lahore. One of the ancient cities of Punjab, Sialkot district is bounded on the north-west by Gujrat district, on the north & north-east by Indian occupied Jammu and Kashmir state, on the east & south-east by Narowal district, on

the west & south-west by Gujranwala district and on the south, it just touches the boundary of Sheikhpura district. The climate of the district is hot in summer and cool in winter. June and January are the hottest and coldest months, respectively. Sialkot is one of the major industrial cities in Punjab and is considered one of the notable centers of the leather industry in the country. There are around 240 tanneries existing in 10 clusters in and around Sialkot.



Figure 30.1. Modair Pur site located at latitude 32.48278 and 74.37450 longitude.

The rapid industrialization of Sialkot has caused threats to the environment and the management of hazardous releases from the tanning units is getting difficult, to protect the environment and safeguarding public health. In the absence of an environmentally sound land fill, a proper effluent collection system and treatment facilities, the effluents of these tanneries are being discharged to seasonal nullahs like Aik, Bhed, and Pulkhu. However, recently a multifunctional Sialkot Tannery Zone (STZ) in the outskirts of Sialkot city has been established, with involvement of stakeholders and active participation and lead by Sialkot Tannery Association (Atif; STA 2019).

Modair Pur site was located in the outskirts of the city (about 40minute drive) near Sambrial, along Wazirabad road (Latitude: 32.48278; Longitude: 74.37450). A large effluent (gray color) stream made its way through the area (Figures 30.1 & 30.2)) and nearby agricultural fields. The quality of both soil and sub-surface water at the site (around 5 hectare), very likely had been affected by the hazardous chemical contaminants in waste water/effluents discharges from the tanning units.

Grab samples of waste water/effluents and soil from around the site/stream were collected by the SDPI ISA team for chemical examination/laboratory tests (Figure 30.2). Analytical testing reports (ATRs) of the composite samples, indicated presence of sulfide (20.12. ppm.) and chromium (total 5.53 ppm) in the studied soil samples. pH of the waste water/effluent was

found to be 7.6 and total chromium content 1.64 mg/liter (chromium VI 0.96; chromium III 0.68. mg/liter). Phenol and sulfide contents in the examined waste water/effluents samples were indicated to be 15.38 and 1.98 mg/liter, respectively (CPC ATRs 2010).



Figure 30.2: Sampling at Modair Pur site

Earlier published data by several researchers, has indicated the presence of Chromium, Sulfide, Phenol and other chemical contaminants in underground water, at some sampling points in/close to the tannery areas in Sialkot (Junaid et al 2017; Ali et al 2015; Qadir & Malik 2011; Rafiq et al 2010; Ullah et al 2009). There could be more than one exposure pathways, through which hazardous chemicals may find their way into human body, causing adverse impacts to the health of local population (about 10, 000), especially of the children and vulnerable population (section 1.1.)

Talking to SDPI ISA visiting team, Assistant Professor at Government Islamia Degree college, Sambrial, Sialkot said, “*Business/working approach of tanneries owners was not an environmentally friendly approach. Effluent treatment should be carried out at point source, each tannery unit must have a treatment plant and farmers in the site area should not irrigate their farms with the contaminated waste water.*” He was of the view that Nala Palku was not directly contaminated, as there was no industry in the upper catchment area, however, its contamination was from different point source, resulting in its physical, chemical and biological changes. “*At downstream no fish was found with seasonal fluctuation,*” he further added and emphasized awareness raising of public in general and local residents in particular, regarding exposure and hazards of the waste site and participation/involvement of the local community, NGOs, CBOs in decision-making. The Vice Principal of the same college was also very much concerned, regarding so many tanneries operating in/outskirts of Sialkot city

and with all the health risks to the residents of Sambrial, caused by the pollution, resulting from the waste released by the tanning units.

3.7.2. Muzaffar Pur Hazardous site

Muzaffar Pur site, Wazirabad Road, was also in the outskirts of main Sialkot city, not far away from the Modair Pur site (3.8.1.) described in the preceding pages (Latitude: 32.47737; Longitude: 74.39944). The site was a legacy site but also somewhat partly active. The surrounding land area (about 600 square meters) seemed all contaminated due to hazardous chemicals containing waste water/effluents discharged from the tanning units for many years.



Figure 31.1. Muzaffar Pur site located at



Figure 31.2 SDPI ISA team with local stakeholders, Latitude 32.47737 & 74.39944 longitude in Sialkot

Grab waste water samples and composite soil samples (surface soil) from around the site area were collected by the SDPI ISA visiting team for chemical examination/laboratory tests. Analytical tests reports (ATRs) of the composite samples, indicated total chromium 0.05, chromium VI 0.04 and chromium III 0.01 mg/liter, in the studied waste water samples. pH of the waste water/effluents samples was found to be 6.9 and the studied samples also showed the presence of phenols (0.28 mg/liter) and sulfide (1.98 mg/liter). In the soil samples collected from the Muzaffar Pur site, total chromium and phenol contents were found to be < 1ppm and 7 ppm, respectively (CPC ATRs 2010). The pathways for human exposure to chemical contaminants could be either of air, water, soil, food, dermal contact and via inhalation and could cause adverse impacts to public health (section 1.1.).

Local farmers/field workers informed the visiting SDPI ISA team that *the land surrounding the site was fertile and bumper crops (especially wheat) grew on it but* due to chemical contaminants in waste water/effluents,

discharged from the tanning units over the years, the same land turned contaminated, barren and no more used for cultivation.” The District officer (environment), Sialkot talking to the team, lamented, “*There was no proper leather waste disposal system in the area.*”

3.7.3. Sahu Wala Hazardous site

Sahu Wala site (Figure 32.1.), located at Wazirabad road, was about 30 minute drive from the main city. (Latitude: 32.48575; Longitude: 74.38757). There was a cluster of about 40 tanneries in the vicinity of the site (area around 1,000 m²) and over the years, the discharged waste water/effluents, containing hazardous chemicals from these tanning units, had contaminated both the land and underground water in and around the site area. The contamination of the underground water was thought to be due to seepage of waste effluents from tanning units in the area. The local population (estimated 100, 000) at the site area used the ground water through water pumps or bore well to meet the day to day household water needs.



Figure32.1. Sahu Wala site located at latitude 32.48575 and 74.38757 longitude.

Like other similar sites in the vicinity of tanneries, the fertility of the soil, was most likely also severely affected by the discharged waste water/effluents, resulting in decreased food crops productivity.

Grab Samples of soil and waste water/effluents from 4 & 3 sampling points, respectively, around the site/pond were collected by the SDPI ISA team for chemical examination/laboratory tests. Analytical testing reports (ATRs) of composite samples, indicated presence of sulfide (15.82 ppm) and chromium (total 1.0 ppm) in the studied soil samples. pH of the waste water/effluent was found to be 7.5 and total chromium 0.05 mg/liter (chromium VI 0.03; chromium III 0.02. mg/liter). Phenol and sulfide contents in the waste water/effluents were found to be 0.55 and 0.58 mg/liter, respectively (CPC ATRs 2010). The likely adverse health impacts on human and diseases

caused by exposure to these chemicals, have already been described in details (section 1.1.).



Figure32.2. Meetings with stakeholders.

A local resident informed SDPI ISA team, “The groundwater level was around 45 feet (about 5 years ago) which depth decreased to about 80 feet, indicating dependence of the local population (around 100, 000) at/around the site area, on ground water to meet their needs for various purposes.” The team was informed that recently, a brick-lined drain for waste water/effluents was constructed by the tannery owner/s. During discussion at his office, the Chairman, Pakistan Gloves Manufacturers & Exporter Association (PGMEA), Sialkot expressed keen interest for managing the tanneries effluent properly and appreciated the efforts by the Clean Production Center, Sialkot, in providing technical support to the tanneries as well as in the establishment of a chrome recovery plant “There should be a collective effort from all the stakeholders to meet the challenges of pollution and risk to public health caused by tanneries in Sialkot,” he added.

3.7.4. Malik-e-Kalan Hazardous site

Malk-e- Kalan site (Figure 33.1) of about 1,000 m² was situated in the middle of residential area (Latitude: 32.47651; Longitude:74.50049). A drain with chemical effluents/waste water discharged from the nearby tanning units which passed through the residential area. There was a Government middle school for the girls (enrollment > 600) just at the bank of the drain and also two mosques in nearby adjacent area (local population approximately 100, 000). Grab samples of waste water/effluents, soil and drinking water (3 sampling points), from around the site/drain/residential area were collected by the visiting SDPI ISA team for laboratory tests and chemical examination (Figure 33.2).



Figure 33.1 Malik-e-Kalan site located at latitude 32.47651 and 74.50049 longitude.

Analytical tests reports (ATRs) of the composite waste water/effluent samples indicated pH 7.1 and total chromium, chromium (VI) & chromium (III) contents 0.021, 0.011 & 0.01 mg/liter, respectively. In the studied soil samples of Malik-e-Kalan site, the sulfide content was found to be 18 ppm and total chromium 5 ppm. The pH of the collected drinking water samples was in the range 6.8 – 7.1 and total chromium 0.06 mg/liter (CPC ATRs 2010).

Like other similar sites (close to the tanning units) in Sialkot areas, visited by the SDPI ISA team during the present study, at this site also the soil and underground water quality in/around the area would be expected to be affected by hazardous chemicals in the effluents/waste water, continuously discharged from the nearby tanning units. Through multiple exposure pathways (section 1.1.), the health of the local population would most likely be at risk. A local resident (male), living since past 25 years at the site area, shared with the SDPI ISA team, “*The chest-disease were common and also some cases of cancer had been reported among the local population.*”



Figure 33.2 Soil sampling at Malik-e-Kalan site



Figure 33.3 Girls school at the site

A female teacher at Government middle school for girls, adjacent to the open wastewater/effluents drain site (Figure 33.3) informed the visiting team about many health problems due to the drain which passed through the residential area and people residing in the site vicinity, lived on with foul odor most of the time all-around. *“The underground water in some localities was clear at 85 feet depth but at 45 feet was found to be yellowish and of poor quality for drinking/domestic use,”* she added. We were informed that even the otherwise clear water at 85 feet depth, would turn yellowish if left in open and not used for a few days. It’s frequent use was considered to be the cause of water borne diseases, skin diseases, eye allergies and some reported cases of cancer among the local population.

3.7.5. Rohail Garh Hazardous site

Rohail Garh site (Figure 34.1 & 34.2), both an active site and legacy site (approximate area 5 hectares) was located in a mix of residential and cultivated areas (Latitude: 32.48499; Longitude: 74.52664). There were a number of medium sized tanning units at the site, besides, a large piece of unused land, exposed to the directly discharged waste water/effluents from the tanneries on it, from time to time. There were heaps and heaps of chromium contaminated residual leather cuttings and shaver dust wastes (Figure 34.2) at the site.

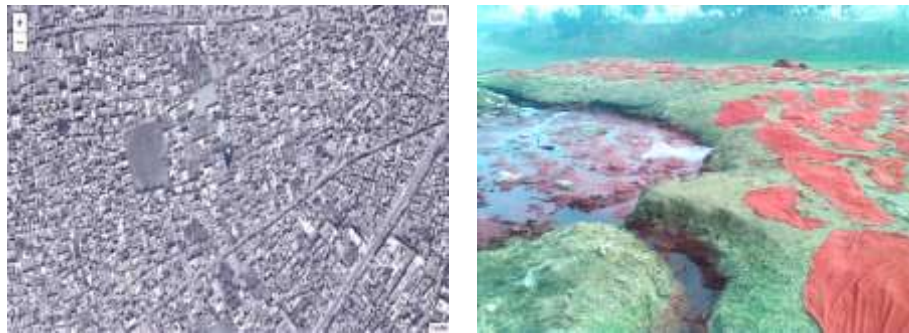


Figure 34.1 Rohail Garh site located at latitude 32.48499 and 74.52664 longitude.

The mixed leather waste was either taken/sold, as cheap fuel for brick-kilns or set to fire in the open (polluting air, affecting about 30, 000 residents in the surrounding areas) to empty space for throwing away more such solid wastes on the land, being continuously generated by the nearby tanning units at the site. The hides after dyeing & follow up finishing processes were spread for drying in open on the land for drying. Another additional source of environmental pollution at the site was the “Wet blue” tanning (dyeing the

preliminary processed hides brought from elsewhere , with chromium), thus further deteriorating the quality of already stressed environment and the resulting threat to the health of the local population living in the close vicinity of the site (estimated population 300/ households, around 60 - 70).



Figure 34.2: Sampling site at Rohail Garh



Figure 34.3: Interview with the local resident

Waste water grab samples (from 4 sampling points) and soil samples (both dry & wet-sledge) from 5 sampling points around the site area (Figure 34.2) were collected by the SDPI ISA team for chemical examination/laboratory tests. Analytical tests reports (ATRs) of composite samples, indicated total chromium 0.06, chromium (VI) 0.01 and chromium (III) 0.05 mg/liter in the studied waste water/effluents samples (CPC ATRs 2010). pH of the waste water/effluents samples was found to be 7.1 and these samples also showed presence of phenols (0.16 mg/liter) and sulfide (0.05 mg/liter). Both the wet (sledge) and dry soil samples collected from Rohail Garh site indicated the presence of total chromium (wet/sledge 14 ppm; dry 2 ppm) and sulfide (wet/sledge 20 ppm; dry 13 ppm). The site could be a point source of environmental and health problems among local population residing in the area, due to the chemical contaminants present in soil & effluents/waste water (releases from the tanneries) via drinking water path way. The most likely health impacts could be skin & eyes diseases and allergic reactions (section 1.1.)

A local farmer (female 45 years of age), residing in the area, complained to the SDPI ISA team of her family facing all time inconvenience of living with the foul odor, caused by burning of the hides/leather cuttings waste at the site. She had been suffering from chronic cough and eye allergy. “The taste of water taken from nearby tube well and hand pump was of poor quality and somewhat turned bitter over the past few years,” she said.

SDPI ISA visiting team had thorough discussion with two key stakeholders in the District Sialkot – the District Officer environment, Sialkot and Manager, Cleaner Production Centre, Sialkot (a project of the Export Promotion Bureau, Government of Pakistan). Their views, comments & suggestions are summarized below:

- Generally, lack of reliable data regarding tanneries operating in Sialkot; no segregation of tanneries waste and municipal waste; waste water/effluents thrown away in nearby vicinity, without any adequate management and pre-treatment.
- Underground water chemically contaminated at location/s in Sialkot district at around 40 feet depth; water of the nearby river partly colored due to the discharged waste water/effluents directly into it; Nala Palkoo carried the waste water into the river at Khanki (irrigated/cultivated land area, close to Wazirabad); some tannery owners having deep injection wells for the released waste water/effluents, thus contaminating the underground water reservoirs.
- Need of establishing a district baseline profile; establishment of proper leather waste disposal system (including a sanitary landfill) in the area; inadequate staff at district environment office, Sialkot.

Establishment of the Cleaner Production Center, Sialkot was a right step in the right direction which effectiveness could be further enhanced with relevant legislation support. There was a dire need for establishment of “Tannery Industrial Zone (TIZ),” with a common/joint effluents/waste water treatment facility, for all tanning units located in TIZ.

Chapter 4

4. SINDH

In Sindh province seven sites, 2 in/outskirts of Hyderabad, one in Tando Muhammad Khan and 4 in/around Karachi, were visited for the initial site assessment (ISA) by the 3-members SDPI ISA team. Brief information about these districts has been taken from the respective district website and the same may be visited for any further details/updates. Earlier published data by several researchers, has indicated the presence of Chromium, Sulfide, Phenol and other chemical contaminants in underground water, at some sampling points in/close to the tannery areas in Sindh (section 1.2.3/Sindh). As requested, the names & affiliations of some of the stakeholders interviewed (available with SDPI ISA team and on records) are not given in the foregoing pages.

4.1. HYDERABAD

The two sites visited in the outskirts of Hyderabad were located at Wakeel Darya Khan and

Haji Darya Khan Panwar.

4.1.1. Hazardous waste dumping site Wakeel Darya Khan

Hyderabad is bounded on the north by Nawabshah district, on the east by Mirpur Khas & Sanghar districts, on the south Badin district and on the west by Dadu & Thatta districts. The total area of the district is 5519 square kilometers and according to census held in 2017, population of district is 2,201,079 with 435,209 households. Hyderabad district is a part of the Lower Indus Plain which is vast alluvial along the course of Indus. The climate of the district is on the whole moderate. The only river flowing in the district is the Indus, which runs along the western boundary of the district. Hyderabad is basically an agricultural district. The visited site was situated, just besides the residential area known as Wakil Darya Khan as it was adjacent to the village Wakeel Darya Khan on one side (Figure 35.1). The waste site, in about 5 hectares area (Latitude: 25:37837; longitude: 68:37275) was like open-air, a series of scattered small blacksmith's workshop units, where different types of small as well as large old/end of life batteries were brought,

both from the local Sindh markets, other parts of the country and also the imported wastes batteries from outside the country.



Figure 35.1 The huge dumpsite located at latitude 25 7837 and 68.37275 longitude.

As observed by the SDPI ISA visiting team, these were dismantled/ recycled through environmentally most unsound/unfriendly practices, to get any reusable components (Figure 35.2).



Figure 35.2 Dismantling/Breaking up of batteries

Figure 35.3 Sampling at Phuleli Canal

The site was nearby Phuleli canal (Figure 35.3) and on the bank of the canal, there were small kilns like spots, where these batteries were dismantled, fragmented and melted to extract reusable material, including lead/copper metals. The activity points were termed "Process Plots" (around 2000 at different locations at the site) where 10-15 adults & children workers (Figure 35.2) per plot worked. SDPI ISA visiting team was informed that the activity had been going on at the site for past more than 30 years. During dismantling/breaking up of the waste batteries, air was polluted with foul smell and dense smoke, hazardous not only to the health of the workers, having no personal protective equipment (PPEs), but also for the local residents (around 1000) in the site area and villages nearby. The leftover residual waste from the process, seemed thrown or as likely run-offs,

(during/after rain) into the Phuleli canal, polluting its water, a vital source of fresh potable and irrigation water for the District Hyderabad (Figure 35.3).

Waste water, soil & canal water grab samples at the site area (Figure 35.3) were collected by the visiting SDPI ISA team, for chemical examination/laboratory tests. Findings of the analytical testing reports (ATRs) of the composite samples, indicated presence of chromium, zinc, cadmium and a very high content of lead in the studied contaminated soil (with metal wastes spread around) at Wakeel Darya Khan site. ATRs of canal water (used for human & cattle /household needs) and waste water composite samples also indicated the presence of Zinc (0.08 mg/liter) & (0.03 mg/liter) respectively (CPC ATRs 2011). Health impacts of these metals such as skin diseases, cancer, allergic reactions, neurological disturbances, memory loss, learning disabilities, low hemoglobin level and chest diseases have been described in details in the preceding pages (Section 1.1). Among the local residents, the diseases of lungs and intestine were reported to be common at/around the site.

During talking with the SDPI ISA visiting team at the site, a worker (35 years age) working at the site for over 4 years said, *“Daily 15 metric tons of batteries are melted in 10 drum kilns resulting in 10 metric tons of recovered material and 5 tons of residual waste, often thrown in to the Phuleli canal. The heaps of residual waste are sold for 1000-1200 PK Rupees. (about 10 – 12 USD), to be generally used for building construction,”* Interviews were also held with officials of EPA, Sindh, representatives of BDRO – a local NGO, and Principal of the local high school who were all concerned and emphasized the need for strict prohibition of import of waste/end of life batteries through the development of necessary legislative measures and control.

4.1.2. Hazardous waste dumping site Haji Darya Khan, Panwar

The site (Figure 36.1) was situated at the outskirts of district Hyderabad, few kilometers away from industrial zone but right in the middle of densely populated residential area and agricultural land around (Latitude : 25.37292; Longitude: 68.39581). The specific site (in more than five hectares area) was a big lagoon having wastewater discharged through a large pipe, coming from the nearby industrial zone comprised of several industries, mainly paper mills, tanneries and textile mills.



Figure 36.1 The huge dumpsite located at latitude 25.37292 and 68.39581 longitude.

The main source of water for the local residents, the Phuleli canal, flowed close by the site. The municipal and industrial wastes had been dumped into the canal. The small extension of Phulaili canal, the Qaziabad canal, also turned into dump site for municipal waste from the nearby residential areas, including Matli city (Badin district) located at canal bank (Soomro & Khumbhar 2009). Grabe samples of Waste water (3 sampling points), soil (3 sampling points) & canal water (2 sampling points) at the site area (Figure 36.2) were collected by the visiting SDPI ISA team, for chemical examination/laboratory tests.



Figure 36.2 SDPI ISA team at dumpsite Haji Darya Khan

Analytical testing reports of studied composite soil samples indicated high level of lead contamination as well as the presence of chromium and cadmium. Composite waste water samples showed 0.20 mg/liter cadmium and 0.04 mg/liter chromium contents. In the canal water, both chromium and lead contents were observed below the WHO & PCRWR standards, for drinking water (ATRs, CPC 2011). These contaminants pathways to impact public health were most likely using contaminated water for household needs, dermal contact and ingestion via food and drinking of water. Canal water contaminated with industrial effluents has also been in use for agricultural purposes and may also be affecting the quality of food crops consumed by the

population around. Reported health impacts conveyed to the visiting SDPI ISA team, by the local residents, were skin diseases, allergic reactions, water-borne diseases, such as malaria, typhoid, hepatitis and cholera (section 1.1.). In addition, the nearby residents in the vicinity of the site and surrounding areas had to live with the bad odor most of the time (estimated population around 7000).

During an interview with the visiting SDPI ISA team at site, a local female resident shared, *“Females were more affected, in terms of added work burden of taking care of sick children and family members, due to water borne disease, resulting from the hazardous waste site exposure .There was a dire need to raise awareness of such public health issues, for which no efforts made so far.”* According to EPA, Sindh officials, *“Tanneries around the site area were usually operating 18 hours/ day, during peak raw material availability seasons, hence increasing the pollution load in the nearby water bodies, due to released waste water/effluents by the respective industrial units.”* The CEO, BDRO, a local NGO informed the visiting team that Ramsar site, near Narari lagoon, was an affected site due to the contaminated waste water/effluents discharge from the close by sugar mill in the area.

Despite the alarming adverse impacts on public health, resulting from the continuous effluents/waste water discharged at the site from various industrial units in the area, there seemed no efforts made towards installation of a combined effluents/waste water treatment plant or any plans under consideration, to shift the operating industries to another site or establish another appropriate alternate site for environmentally sound waste management.

4.2. TANDO MUHAMMAD KHAN

The one site visited in Tando Muhammad Khan district was located at Tando Ghulam Haider Tehleko.

4.2.1. Hazardous site, Tando Ghulam Haider Tehleko,

Tando Muhammad khan, located in Northern part of Sindh province, is about 20 miles from the Sindh Province second largest city, Hyderabad. It is surrounded by Sujawal district on its West, Badin in South East and Tando Allah Yar &Hyderabad districts in the North. Indus river flows through Northwest. Climate of the area is moderate. Population mostly engaged in agriculture. The assessed site was a long drain (Figure 37.1)), beside a sugar

factory boundary wall, along Hyderabad - Badin link road, in the near vicinity of agricultural land & residential areas, including a children school (Latitude 25.61201; Longitude 69.56758). The mostly filled up drain had brownish golden color waste water/effluents discharged from the adjacent sugar mill.



Figure 37.1 Huge dumpsite located at latitude 25.61201 and 69.56758 longitude

The extremely foul odor around the long drain was simply unbearable for the visiting SDPI ISA team (even in the moving vehicle) and an all-time source of great nuisance to the passersby and local residents. It was obvious that during rainy season, the overflowed drain waste water, contaminating the agricultural land, underground water and the nearby canal water. Grab waste water samples from 3 sampling points along the drain were collected by the SDPI ISA team for chemical examination/laboratory tests (Figure 37.2). Analytical testing reports of the studied drain waste water composite samples, among others confirmed the presence of chromium and high sulfide content - 0.77 mg /liter (ATR CPC 2011).The close by canal water quality likely to be affected by the contaminants present in the discharged sugar mill wastewater & effluent, also resulting in affecting the cultivated crops in the surrounding agricultural fields around the site.



Figure 37.2 Wastewater sampling at site and after the interview with stakeholders at site.

The principal of a local girls high school, while talking with the visiting team said, “There was no waste water/effluents treatment methodology employed at the site, resulting in the contamination of the sub-surface water in the area which was contaminated and no more suitable for drinking purposes or other household needs.” She further added that as the local residents continued to use it (brackish water) and also the likely contaminated fish caught from the canal, due to chemical contaminations of both, the local fish & water, the public health was affected. There were reports of kidney, hepatitis, skin diseases, eyes irritation, hair color and lungs health related problems among the local residents.

The CEO, BDRO (a local NGO) expressed his concerns about the health impacts resulting from the hazardous site during an interview with the SDPI ISA team and said, “ Local population living in the five nearby villages in the area, had been affected due to the hazardous impacts of almost all time running contaminated drain and the solid waste mud discharged from the sugar mill.”“ The reduced fish catch in the area had affected the livelihood of the local fishermen” he further added.

Besides, degrading the essential segments of environment around and the resulting impacts on public health and the site being most inconvenient to passersby and local residents of the surrounding areas for many years, no efforts to redress the situation seemed to have been made by the well reputed prosperous sugar mill management. Interviews were also held with local residents at and around the site as well as with officials of EPA, Sindh, Karachi. Waste reduction at source, with best environmental practices (BEP) within the sugar factory and immediate installation of an effluent treatment plant, were considered most viable options, to protect the environment and reduce the hazardous exposure for safeguarding the local population health, especially of the children.

4.3. KARACHI

Four sites were visited in/around Karachi at Keamari, Chamara Chorangi, Korangi Creek and Sher Payo Colony.

4.3.1. Keamari Coal Dumping Site

Karachi, the provincial capital of Sindh, is also the largest city of Pakistan covering an area of 3,527 km². It is bounded by 2 districts in Sindh Province Dadu (northeast), Thatta (south-east) and Lasbela (in Baluchistan Province) and the Arabian Sea in the south.. Karachi is the most populous city of

Pakistan and country's premier center of banking, industry, trade and is home to Pakistan's largest corporations, including those involved in textiles, shipping and automotive industry. All streams that flow in the city are ephemeral. The Liyari River falls in Keamari and Malir River falls in Gizri Creek. Population is estimated around 20 million. Located on the coast, Karachi has a tropical/arid climate with low average precipitation levels. Winters are warm and dry, while the summers are hot and humid; the proximity to the sea maintains cool sea breezes which relieves the heat of the summer months. Karachi has a moderately temperate climate.



Figure 38.1 The huge coal dumpsite located at latitude 24.81523 and 66.98129 longitude

The site (Figure 38.1) was at about one-hour travel by road from main Karachi, about 3 km away from Keamari town and 1 km away from the dockyard, from where the unloading of coal from ships took place. It was a huge open coal dumping site (Latitude 24.81523 and Longitude 66.98129), covering an area of more than 5 hectares. An estimated 1,50,000 metric tons/day coal being unloaded at this site and sent to commercial users across the country, mostly employing trucks.

The site has been very active since 2004, the main reason was the energy crisis in the country and coal was considered as the cheaper source of energy, compared to alternative fuels like oil or gas. Coal was imported from different countries like Indonesia, Malaysia, and South Africa etc. to meet the energy requirements of industrial sector, mainly cement factories and also for use in brick kilns. More than 200 people worked at the site (estimated local residents around 35,000). There was open unregulated coal dumping at the site, resulting in high particulates content (coal dust/particles) in the air which quality in and around the site would expected to be poor and hazardous to the health of the workers and the local residents in the area. Layers of settled coal dust/particles could well be seen on the floors and inside walls of some government offices building nearby the site. Air was the most likely pathway

for the particulates (coal particles/dust) affecting public health. SDPI ISA team was informed of the diseases of the chest, skin, eyes which were common among the local residents in/around the site area.

During an interview, the Traffic in-charge/Supervisor at Keamari Port Trust office (about 1.5 kilometer distance from the coal dumpsite) informed the SDPI ISA team, *“About 40 million tons of coal was unloaded per month at the port and dumped at the open site. The reported air-borne diseases in/around the site area were chest, skin and eye diseases, besides cases of lung cancer and allergic reactions.”* Doctor at Dehi Markaz-e-Sahat (Rural Health Center) Keamari Town said, *“Mostly patients visiting the center had fever & flu. However, asthma was common in this area and patients with the symptoms of asthma were advised for complete examination at the city civil hospitals”*. CEO of one of the oldest and established NGO lamented, *“Government was unable to focus on remediation of the sites. Some local existing Networks could be employed for mobilization of the stakeholders towards remediation of the contaminated sites.”*

According to news agencies report, the coal dust was damaging for the environment, including the marine ecosystem. The dumping and loading of coal in Keamari discharged large quantities of coal soot into the atmosphere, which was carried far and wide by the wind and polluting the sea-belt and was destructive for the marine life (News-agencies 2010) There appeared a very dire need for environmental and health assessment at contaminated sites, environmentally sound management of industrial waste, including periodic air monitoring and evaluation and detoxification of the hazardous waste at the earliest time possible, through joint efforts and collaboration of EPA, Port Trust Authority Sind and other relevant stakeholders.

4.3.2 Mehran Town Site, Sharif Abad

The visited site (Figure 39.1), about 10-12 kilometers away from Karachi Saddar (Contonment) area, was a drain in the Korangi Industrial area (close to the oil refinery at Chamara Korngi), where waste water of the nearby factories, including oil refinery, had been discharged into the drain. The drain with chemically contaminated waste water, was spread along the main road (Latitude 24.86540; Longitude 67.10979) and in the close vicinity of slum as well as a residential area, namely Bilal colony (estimated households around 5,000). Grab waste water samples from 2 sampling points along the drain

were collected by the SDPI ISA team for chemical examination/laboratory tests (Figure 39.2). Analytical testing reports of the studied composite drain waste water samples, among others confirmed the presence of chromium (0.12 mg/liter) and high lead content 1.12 mg lead/liter (ATR CPC 2011).

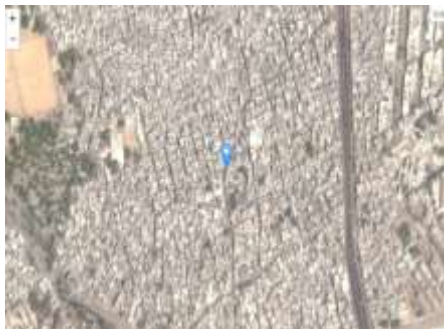


Figure 39.1 Drain site, M/Town located at latitude 24.86540 and 67. 10979 longitude



Figure 39.2 Waste water sampling at site

Figure 39.3 Meeting with stakeholders

SDPI ISA team was informed that during rainy season, the drain overflowed into the residential as well as open land, among others, most likely contaminating drinking water sources and the resulting water borne diseases among the local population, as explained in Section 1.1. According to a female representative of a local NGO, *“The Government should pay attention to the remediation of the contaminated sites in Sindh and elsewhere, to safeguard public health and for the protection of environment.”* During meeting with the officials of EPA Sindh, Karachi, the challenges faced by the agency were pointed out, such as the strict implementation of environmental laws, influence/pressure of the industrial sector and the maintenance/smooth functioning of a combined effluent treatment plant. According to EPA Sindh officials, *“For combined treatment plant, the awareness & the need was, however, growing up among industrialists and very soon majority of them would be willing to contribute/pay the treatment cost of their respective industrial units waste released at the site.”*

As was also observed at some other waste sites, during Mehran site visit, SDPI ISA team also observed that despite the site effluent discharge, mostly or fully, coming from a nearby well established and highly profiteering industrial unit, no efforts seemed to have been made, with regard to installation of an effluent treatment plant at the site or shifting the disposal site away from the residential area.

4.3.2. Korangi Creek Site

The site (Figure 40.1) at Korangi Creek drain, was not far away from previous site at Meharan Town (4.3.2.).



Figure 40.1 Drain site, K/Creek, located at latitude 24.80556 and 67. 13198 longitude

It was located adjacent to a well-known & reputed academic institution (around 4000 students), in the Korangi creek area (Latitude: 24.80556; Longitude: 67.13198). A large oil refinery was located on the opposite side of the drain. Bhattayi colony, a residential area (approximately 6-7 thousand households) was also located closer to the site. The dark colored chemically contaminated effluents/waste water, mostly flowed into this drain, from Karachi industrial and trading areas as well as factories scattered at different locations in the area.

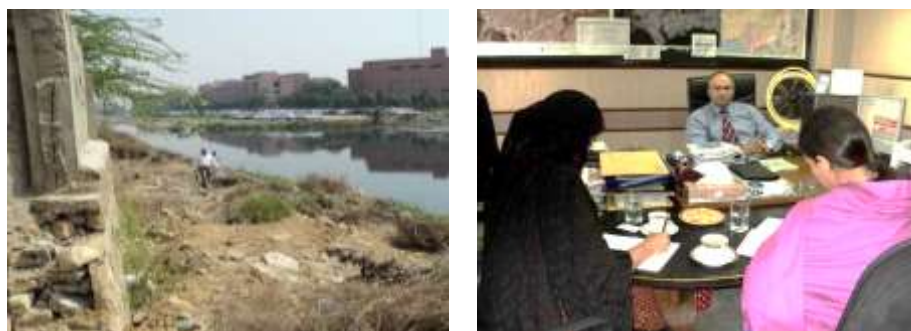


Figure 40.2. SDPI ISA visiting team at the K/Creek for waste water sampling & meeting stakeholders

Grab waste water samples from 2 sampling points along the drain were collected by the SDPI ISA team for chemical examination/laboratory tests (Figure 40.2). Analytical testing reports of the studied composite drain waste water samples, among others, confirmed the presence of high lead content 1.22 mg lead/liter (ATR CPC 2011). This drain, with the chemically contaminated waste water/effluents and passing through different residential areas, posed serious health hazards to the students of the nearby educational institution and local population. Local population (estimated around 39000) could be at risk, due to likely air- and water-borne diseases (section 1.1.), resulting from the poor quality of air & water around the contaminated site areas.

During an interview with SDPI ISA team, the Professor of the nearby educational institution said, "*Korangi Industrial and Trading Estate (KITE) and Sindh Industrial and Trading Estate (SITE) were the potential contaminated area and due to increasing level of pollution, the public health concerns were being raised by the local residents, especially, as a result of drinking water getting contaminated.*" According to him, the oil refinery located in the area, was also enhancing pollution, due to leakage/s from the refinery pipe, affecting sub-surface water. At this site also there was a need to prioritize the establishment of a combined effluent treatment plant at the earliest time possible, with initiatives from the local stakeholders (including the well reputed educational institutions and the prosperous oil refinery management), to safeguard public health (estimated population at risk 39, 000) and environment protection.

4.3.3. Sher Payo Colony Site

The site (Figure 41.1) having an approximate area of 1,000 m², was another long drain carrying the industrial effluents/waste water from many textile mills in the area. (Latitude: 24.80997; Longitude: 67.18935). The drain being partly covered was not visible from its origin but flowed through the residential area, known as Sher Payo Colony (estimated population about 5000). Grab waste water samples from the drain and surrounding soil samples were collected by the SDPI ISA team for chemical examination/laboratory tests (Figure 41.2). Analytical testing reports of the studied composite drain waste water samples, among others confirmed the presence of Chromium (0.04 mg/liter) and lead content (0.92 mg lead/liter).



Figure 41.1 Drain site, S/Colony, located at latitude 24.80997 and 67. 18935 longitude

Composite soil samples also indicated chromium content (1.20 mg/Kgm) and lead content (182. 25 mg/Kgm) (ATR CPC 2011). During rainy season, the flooded drain overflow would most likely be contaminating water sources in the area and the standing waste water around, resulting in water borne diseases among the local population, due to its chemical contaminants (Section 1.1). Like some other similar sites visited (described in the preceding pages), here also, SDPI ISA team observed that despite the site receiving effluents & waste water discharges of well-established textile units in the area, no efforts seemed to have been made towards installation of a treatment plant or shifting of the disposal site away from the residential area.

A local resident (since 1990) while talking to the visiting SDPI ISA team at the site said, *“Despite the site being partly covered, among others, it was also affecting the air quality around.”* The Chairman of an established Group of companies was of the view, *“Waste management should be a priority and the industrial waste should be managed after careful analysis and data collection.”* He was also of the view that the detoxification of hazardous waste was very important and proposed that *“Bioremediation”*



Figure 41.2.SDPI ISA team interviewing local stakeholders.

could be one of feasible options. Representatives of a reputed NGO were of strong views that Government should pay attention on remediation of the hazardous sites, for which support of the Network of local NGOs was readily available. The drainages should be either fully covered/ bricks lined to prevent soil and water getting contaminated in the surrounding areas. SDPI ISA team also interviewed representatives of some local environmental consulting firms in Karachi and were informed, *“Almost all the water bodies, nearby industrial areas SITE, KITE, FB, West Wharf , North Karachi, Landi were contaminated and the SITE industrial estate was more prone to contamination.”* Generally, options available in Karachi regarding the waste management were considered to be, either to sell/manage it through private contractors or to dump directly to the landfill sites, including Gon Pass (near Baluchistan) and Jan Chakro. Some stakeholders also recommended, engaging multinational companies in tackling the waste management issues.

Chapter 5

WAY FORWARD

Wastes management has long been an issue of critical concern, for the health sector, environmental protection agencies and civic authorities in the country. None of these bodies has the resources, the facilities or expertise to ensure the environmentally sound waste management. Legacy toxic pollution resulting from hazardous waste sites, is rapidly on the increase, damaging the environment as well as threatening the public health, especially, the health of the vulnerable population. The completed initial site assessment of 38 sites, described and discussed in the preceding pages has also indicated growing significant risk, both to the environment & health of the people in general and those living in the near vicinity and around the investigated sites in particular. It's well established that public health in more than one way, ultimately impacts the national economy.

Like most of the other neighboring South Asian countries, Pakistan economy's has also been centered on agriculture. However, in the recent past, manufacturing and services have also emerged as major contributing sectors and the share of manufacturing sector, from 18.3% in 2007 to 30% by 2030 has been envisioned in "Vision 2030" (PC 2007)). Due to poor environmental legislative control and environmentally unsound & unfriendly manufacturing processes adopted by many industries in the country, would further enhance environmental degradation, compound the environmental issues and increase the number of hazardous sites in the country.

Over the years, environmental protection agencies (EPAs) and Ministry of Environment have done well, within most constraint financial and technical resources, by establishing institutions, developing and to the extent possible, implementing with the involvement and support of stakeholders, environment policies, action plans, strategies and legislation to regulate industrial pollution, for the protection of environment and safeguarding public health. Some initiatives and arrangements, with stakeholders joint efforts and substantial technical & financial support, have been the ISO certification of industries, setting up of model cleaner production centers and combined treatment plants for specific industrial sectors, setting up of revised national environmental quality standards (NEQS) for industrial emissions & releases, launching of the self-monitoring and reporting/SMART

program for the industrial sector across the country, requirement of initial environmental examination (IEE)/environment impact assessment (EIA) for new public & private sectors projects, issuing of several environment protection orders (EPOs) to non-compliance industries and the establishment of environmental tribunals in the country (Khwaja et al 2017). It was heartening to observe that the self-monitoring and reporting/SMART program promoted a culture of self-monitoring by industry and reporting the emissions and releases of their respective industrial unit data to provincial EPAs in the country (Khwaja & Quraishi 2003; Khwaja 2017). However the progress on these initiatives and arrangements, though steady for a period of time, has been slow, with varying degree of successes (Khan 2010)

The presence of factories in/around the residential area, discharging chemicals containing effluents/waste water, without any pre-treatment at the site, may continue to cause environmental pollution, affecting public health. The waste problem gets more complicated and serious, as the residents of the surrounding wastes areas are most often very poor, uneducated, lack awareness and also with no health care facilities around (Khwaja 2016). At many studied sites the industrial effluents were discharged into the sewerage system causing adverse health impacts on the local population. A few industrial units employing deep injection wells for the released waste water/effluents further contaminated the underground water reservoirs. At some locations, investigated in the present study, the underground water was chemically contaminated at around 40 feet depth. Water of the nearby water streams at these locations, had turned partly colored due to waste water and effluents discharged directly into the streams. Some seasonal Nallahs, finally carried the waste water into the river, passing by irrigated/cultivated land. There were complained by the local farmers of decreasing soil fertility over past few years due to waste water/ effluents discharged from the industrial units in the area/s. The seemingly, most alarming observation of the visiting SDPI ISA team at some sites was, the likely use of the discharged polluted waste water/effluents from the mills/industrial units, for irrigation, in the agricultural land, generally cultivated for cash crops.

Although some hazardous sites were located in thickly populated residential areas, no effort seemed to have been made by any of the stakeholders, with regard to the management of waste water/discharged effluents. Most of the owners of the industrial units live comfortably far away from these sites in big cities and most likely unaware, as well as least concerned about the

environmental and public health problems/issues, caused by their polluting units, in operation at the site. Business/working approach of the industry owners appeared to be environment unfriendly. For many years, some sites have been most inconvenient to even passersby and the local residents of the surrounding areas, but no efforts to redress the situation seemed to have been made by the management of the well reputed prosperous industrial units & mills situated in the site areas.

Generally, some initial interventions, as required and feasible for the site may include active site controls and treatment, clean up, treatment plant installation, alternate water supply for drinking/domestic needs of the local population, introduction & promotion of water treatment system (including households water treatment), waste dump & contaminated soil removal, soil remediation around the site, training & awareness raising and development, implementation of specific legislation for hazardous sites and further research, if so required (Annex B:BSI/PE).

During discussion of the visiting SDPI ISA team with stakeholders, “Waste Reduction at Source”, with best environmental practices (BEP) within the industrial units/factories and immediate installation of an effluent treatment plant, were considered most viable options, to protect the environment and in reducing the hazardous exposure to safeguard local population health, especially of the children. Preferably effluent treatment may be carried out at point source within the industrial unit. However, because of so many similar industrial units (very especially the textile, tanneries & leather) in the same area, “A joint effluent treatment plant” could be the best feasible option, with support/financial sharing by all stakeholders (industry, government, international bodies, industrial associations etc.). In view of lack of reliable data regarding industrial units, generally and no segregation of the released/discharged industrial waste and the municipal waste, prior to any remedial plan/action at hazardous sites, a detailed research on pollution load would be essential to be carried out, to assess the specificity and quantum of the contamination, the required relevant technology and cost for the same. Experience sharing/technical support may also come from similar plants already operating in/outside the country. For establishing a combined treatment plant at hazardous sites, the awareness & the need appeared to be growing up among many industry owners, as well as willingness to contribute/pay the waste treatment cost of their respective industrial units at the site. Some available options in Karachi and other cities, regarding the waste management were considered to be, either to sell/manage it through

private contractors or to dump directly to the landfill sites. Some stakeholders also recommended, engaging multinational companies in tackling the waste management issues.

Industrial sector should follow country national environmental quality standards (NEQSs), recycle any form of waste/s generated by their industrial units & the chemicals so recovered be reused in their as well as other industrial units. Establishment of the Cleaner Production Centers, like one in Sialkot and a few other main industrial cities in the country, was a right step in the right direction, in promoting best available (green) technology (BET), best environmental practices (BET) and awareness raising about hazardous exposure to public health, resulting from chemically contaminated waste/waste water from the industrial units . The effectiveness of such service providing centers could be further enhanced with relevant legislation support. Due to rapid urbanization and lack of long term foresight & planning, in some cities, the residential areas appeared to be merging into old industrial centers which were far away from the main cities at the time of their establishment. In view of these scattered polluting industrial units, within and close to the vast residential areas, the development of “Industrial Zones” (with a joint industrial effluents/waste water treatment facility), far away from the main cities was planned and sites acquired, to shift the industrial units (especially leather/tanneries & textiles spinning/dyeing) from the main city residential areas to the fast developing industrial zones in the country.

The land in and around the hazardous site (demolished structures, legacy sites areas) must not be sold or put to any residential, commercial, agricultural , children’s park or sports/recreational activities, without an environmental impact assessment (EIA) and the approval of the same by the respective EPAs. Some sites contaminated with organo-chlorine (OC) or other toxic pesticides (in-depth soil contamination) posed serious environmental and health impacts for the local population. Even if all the depleted/obsolete pesticides have been removed from such sites and disposed of , due to the residual chemicals in soil, subsurface water & even in air (closed walls areas, contaminated dust & particulates), the site and its surroundings may require an immediate environmental and health assessment study and in the light of the findings & recommendations , appropriate remediation/control measures (including periodic monitoring and evaluation and soil detoxification) would need to be taken up, to safe guard long term public health, especially of the children.

During discussion with SDPI ISA team, several stakeholders expressed the view that the major barrier in combating the industrial pollution problem in the country was the lack of political will and low priority to the issue by the government. It's time that the political parties in the country give appropriate emphasis, affirm some level of commitment and priority to environmentally sound chemicals and hazardous waste management and towards effectively addressing long awaited environmental issues in the country, to protect environment and safeguard public health in general and of children in particular. SDPI has already initiated holding informative capacity building sessions & meetings on environment, climate change and other issues of national importance, with members of provincial & national assemblies and members of the country Senate. Such initiatives need to be further strengthened with all stakeholders support, their continued interest and meaningful substantial involvement. Besides, the government and industrial sector, "Civil Society" can play a vital role towards industrial pollution control by building awareness, understanding and concern among all stakeholders and sections of society, providing relevant information and help to marginalized and vulnerable groups (women, children, elderly & sick) and by carrying out national and local campaigns and projects that contribute to protecting environment and minimizing public exposure to toxic industrial releases/hazardous waste sites. Civil society needs to be involved to the extent possible, both at the policy development and implementation phases, as has been made obligatory to the national governments/parties to Stockholm Convention on POPs, Strategic Approach to International Chemicals Management (SAICM) and the Minamata Convention on Mercury (MCM) phase out (UNEP Chemicals 2001; 2006; 2013).

In view of having trust of the industrial sector in the country and other stakeholders and years of experience in technology transfer for sustainable industrial development, organizations like SDPI, have the potential for an extended role in implementation of the above recommendation, towards coordination among stakeholders, identifying funding sources and facilitating with information about the appropriate "Technology Transfer" for the remediation of the hazardous sites, identified by the SDPI ISA team in this study. Out of the investigated 38 sites, we strongly recommend the following ten priority sites in the first phase, for which immediate remediation actions are required:

2.1.1.1. Hazardous Waste Dumping Site

2.1. 3.2. Depleted Pesticides Dump

3.1.1. Chenab Drain, Nishat abad

3.2.1. Moosa Wirk

3.3.3. Younis Nagar

3.5.1. Pir Shah Wala, Basti Darkhaana

3.5.4. Shah Town, Sameejabad

3.8.5. Rohail Garah,

4.1.2. Haji Daryan Khan Panwar

4.3.1. Coal Dumping Site

Follow up to the completion of “Global Inventory project” (Site monitoring and Assessment study), Pure Earth, in consultation with international stakeholders in many countries, proposed “Health Pollution Fund (HPF),” to address environment health issues, including hazardous waste sites. HPF will finance remediation of the worst pollution sites, implementing activities that mitigate the most severe impacts to people, especially children. Such proposals and follow up work directly supports the Millennium Development Goals (MDGs), as it would significantly improves health and reduces poverty (Pure Earth, 2010). Several tried and tested methodologies/technologies have been described, reviewed, reported and are accessible for disposal of chemically contaminated toxic wastes, remediation and detoxification of contaminated sites (Hashmi et al 2017; 2018; 2019; Khwaja & Petrlik 2005; Fuller & DiMarco 2015; Weber et al 2013, 2011, 2007; Pure Earth 2010; The Lancet Report/GAHP (2017); selected references section 1.2.).

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Acronyms

AEI	Adverse effect index
ARDS	Acute respiratory distress syndrome
AMC	Ayub Medical Complex
BAC	Bioaccumulation coefficient
BCF	Biological concentration factor
BDRO	Badin Development & Research Organization
CA	Cluster analysis
CDI	Chronic daily intake
DA	Discriminant analysis
dB	Decibel
DDT	Dichlorodiphenyltrichloroethane
DFA	Detrended fluctuation analysis
DG	Director General
DHQ	District Headquarter Hospital
DW	Dry weight
EPA	Environmental Protection Agency
EF	Enrichment factor
ERI	Ecological risk factor
FA	Factor analyses
GAHP	Global Alliance on Health and Pollution
GPS	Global Positioning System
HACA	Hier-archical cluster analysis
HM	Heavy metal
HPF	Health pollution fund
HRI	Health risk factor
KPK	Khyber Pakhtunkhwa
MCM	Minamata Convention on Mercury
NWFP	North-West Frontier Province
NEQs	National environmental quality standards
OCP	Organo –chlorine pesticide
PCA	Principal component analysis
PLI	Pollution load index
PPE	Personnel protective equipment
PCRWR	Pakistan Council of Research in Water and Water Resources
PCSIR	Pakistan Council for Scientific and Industrial Research
PDA	Peshawar Development Authority

PEPA	Pakistan environmental protection agency
PEPA-98	Pakistan environmental protection act 1998
POP	Persistent Organic Pollutants
RI	Risk analysis
RSC	Residual sodium carbonate
SAR	Sodium absorption ratio
SAICM	Strategic approach international chemical management
SBAF	Sediment-biota accumulation factor
SDPI	Sustainable Development Policy Institute
SOD	Superoxide dismutase
TF	Translocation factor
TMA	Tehsil Municipal Administration
TMO	Tehsil Municipal officer
UK	United Kingdom
WHO	World health organization

ANNEX A.

Table No. 1: Selected metals on 2017 ATSDR Priority List of substances

2017 Rank	Substance Name	Total Points	CAS RN
1	Arsenic	1674	7440-38-2
2	Lead	1531	7439-92-1
3	Mercury	1458	7439-97-6
7	Cadmium	1320	7440-43-9
78	Chromium	895	7440-47-3

Source: Agency for Toxic Substances and Disease Registry (ATSDR) www.atsdr.cdc.gov/spl (Visited September, 2019)

Table No.2: Pakistan National Environmental Quality Standards (NEQs) of selected metals/chemicals, for Municipal and Liquid Industrial Effluents

Sr. No	Parameter	Pakistan NEQs (mg/L)		
		Into Inland Water	Into Sewage Treatment	Into Sea
1.	Lead	0.5 mg/l	0.5 mg/l	0.5 mg/l
2.	Mercury	0.01 mg/l.	0.01 mg/l.	0.01 mg/l.
3.	Arsenic	1.0 mg/l.	1.0 mg/l.	1.0 mg/l.
4.	Cadmium	0.1 mg/l.	0.1 mg/l.	0.1 mg/l.
5.	Chromium (trivalent and hexavalent).	1.0 mg/l	1.0 mg/l	1.0 mg/l
6.	Pesticides, herbicides, fungicides and insecticides	0.15 mg/l	0.15 mg/l	0.15 mg/l

Source: Pakistan environmental protection agency (EPA)/Ministry of Climate Change, Islamabad. Pakistan <http://serl.pk/lawfile/23/NEQs-liquid-effluents.pdf> (visited September, 2019).

Table No.3: Permissible limits of selected metals in drinking water

Sr. No	Metals	Drinking-water WHO guideline values (mg/L)
1.	Cadmium	0.005mg/ l
2.	Chromium	0.05 mg/l
3.	Arsenic	0.05 mg/l
4.	Lead	0.05 mg/ l
5.	Mercury	0.001 mg/ l

Reference: Kumar and Puri, 2012


Table 4: Maximum Permissible Limits (MPLs) of Selected Metals in Irrigation Water, Soil and Vegetables (ug/g)

Metals	MPLs in Irrigation water	MPLs in Soil	MPLs in vegetables
Arsenic	0.10	20	0.10
Lead	0.065	100	0.30
Cadmium	0.01	3	0.10
Chromium	0.55	100	
Cobalt	0.05	50	50
Zinc	0.20	300	100
Nickle	1.40	50	67.00

Reference: Ewers 2004

ANNEX B

ISA standardized document (Restricted/All rights reserved)

 **Initial Site Assessment**

Site Name: specific to general (i.e. Agira Metals Company, Nairobi)
Date of Assessment: day, month, year (i.e. 19 March 2009)
Country and Region: Kenya, Africa
Investigator: Mr. Echo

Instructions:

- Fill out this form online at the Blacksmith Site Assessment database (www.hpfund.org/isa) as soon as the site has been visited. The information may be completed over a period of time, but is preferable to be submitted within 24 hours of site visit.
- If the website is not available to you, fill in this Work template and forward it to NY offices upon completion.
- Some data from this form (and the online database) will be available for general public databases, Google included. Those fields are specified clearly, and marked in **BROWN** (or gray if printing in Black and White) and are boxed. Please ensure that text in these fields is appropriate for general public review. If in doubt, refer to New York offices.
- Take photographs (digital, if possible) of all aspects of the site, and forward with report.
- Take water and other samples where appropriate. Sampling methodology must follow Blacksmith guidelines.
- Append copies of all site relevant data collected from meetings.
- Draw, scan, and pdf a site schematic and append with other data.

Part I. Screening Risk Assessment (complete this section last)

Use the Excel document "Blacksmith Scale - Worksheet.xls" to determine Raw Risk Assessment and Blacksmith Scale Ranking Priority

Please note that this information will not be a part of public databases

RAW RISK ASSESMENT (circle one) 1 2 3 4 5 6

BLACKSMITH SCALE RANKING PRIORITY (circle one) 1 2 3 4 5 6

Part II. Physical Description

Location

- List the location of the site (town, village, province) then
- the size in square meters or km then
- information on topography, water bodies and general climate.
- Finally describe the actual site and its pollution problem. Stay focused and be consistent.

Site Description

- Describe topography (hilly, flat, mountainous)
- Describe climate (jungle, arid, dry / wet season)
- Identify any water bodies (rivers, lakes)
- Finally describe the actual site and its pollution problem (include short history if appropriate but report on current site condition)
- Give the site description in general terms first, then more specifically. Identify Active or Legacy.
- Stay focused and be consistent.
- The description should be readily understandable to a non-local reader.

GPS Coordinates and Maps

- If you do not have a GPS, use Google Earth to get coordinates
- Use Decimal Degrees (i.e. Latitude 18.430925 Longitude -70.018769)
- Include a schematic diagram, which should be scanned, pdf'd, and attached.

Pollutants

- List the primary pollutant and source, then (i.e. Chromium from mining operation)
- List all other pollutants, and their sources. (i.e. Cadmium, heavy metals, petroleum hydrocarbons)
- List quantities of sources, where known.
- Note if Active Site or Legacy Site
- Refer to Blacksmith databases as needed.

Contaminant Likely Transmission Path (Air, Water, Soil and/or Food)

- Contact with human population, how is this occurring?
- Other pathways? Other potential pathways?
- Explain all of these.

Number of affected people

- Indicate populations at risk for each pathway
- Indicate maximum potential population at risk

Samples Taken (Location, Type, and Test Results)

- List samples taken, and laboratory sent.
- Append any previous tests by other credible agencies, and indicate test results below.
- Describe where BI samples were taken, and to which pathway they relate.
- Provide results when available to New York, or update on website. This should be done as soon as possible, to finalize Risk Assessment.

Describe credible health impact of pollutant

- Describe what the medical community is reporting
- Has this been documented in any report? Append any existing studies (scan and pdf)
- Indicate anecdotal evidence of human health impact

Additional Notes

Part III. Responsible Parties

List all owners of the site, where known or suspected, most recent first

Organization	Dates of ownership (mm/yy-mm/yy)
1.....
2.....
3.....
4.....
5.....

List these organizations again below with contact information

Owner:
Dates of ownership:
Contact details:

Owner:
Dates of ownership:
Contact details:

Owner:
Dates of ownership:
Contact details:

Owner:
Dates of ownership:
Contact details:

Part IV. Site Stakeholders – Meeting Details
(Continue notes on back or separate sheet if necessary)

Key Government Environmental Agency

- > Contact Details:

- > Meeting Dates, Notes, & Key Findings:

Municipal Authority (Mayor, etc)

- > Contact Details:

- > Meeting Dates, Notes, & Key Findings:

Local Health Facility Director

- > Contact Details:

- > Meeting Dates, Notes, & Key Findings:

NGO/Community Agency

- > Contact Details:

- > Meeting Dates, Notes, & Key Findings:

Business/Corporate Interest

- > Contact Details:

- > Meeting Dates, Notes, & Key Findings:

Other Agency (note details)

- > Contact Details:

- > Meeting Dates, Notes, & Key Findings:

Part V. Expected Intervention Description

Describe short term strategy required to initiate site remediation.

- Outline key players, timeframe, etc

Describe expected likely final remediation plan

- Probably, or range of technologies to be included
- Review Blacksmith "Quick Sheets"
- Timeframe
- Bioremediation evaluation strategies, including likely agency

Note any physical, political or social barriers to remediation efforts.

Who is Local Champion? Provide contact details

*Collect and append the following key information -
Site schematic, including indication of pollutant extent and pathway (scan and pdf)
Existing health studies (scan and pdf)
Other reports gathered
Site photos
Forward completed package to New York offices*

ANNEX C

Contaminated sites (38) studied in Pakistan

1. Khyber Pakhtunkhwa (KPK) Province – Sites in Abbottabad, Nowshera and Peshawar

Salhad; Banda Ali Khan; Aman Garh; Agricultural University and Jamrud Road (5 sites in 3 districts)

2. Islamabad (Federal Capital - Sites in/around Islamabad

Humak and Khanna Dak, Lehtarar (2 sites)

3. Punjab Province – Sites at Faisalabad, Kasur, Khanewal, Lahore, Multan, Rawalpindi, Sahiwal and Sialkot

Nishat Abad; Gokhuwal, Millat Town; Dagrahwa Road; Samandri Road; Jaranwala Road; Johal;

Mian Khuryanwala; Moosa Virk; Bangla Kamboyan; Maan village ;Younis Nagar ;Rohi Nala;

Pir Shah Wala ; Basti Khair Shah; Rehmat Colony; Shah Town; Nullah Lai;

Rajpura; Harappa; Modair Pur; Muzaffar Pur; Sahu Wala; Malik-e-Kalan and Rohail

Garah (24 sites in 8 districts)

4. Sindh – Sites in Hyderabad, Tando Muhammad Khan and Karachi

Wakeel Darya Khan; Haji Darya Khan Panwar; Tando Ghulam Haider Tehleko; Keamari, Chamara Chorangi, Korangi Creek and Sher Payo Colony (7 sites in 3 districts)

BOOK REVIEWS

Dr. Abid Qaiyum Suleri, Executive Director, SDPI, Islamabad. Pakistan

It's a matter of great pleasure and honor to launch this publication on the 28th anniversary of SDPI. Since its inception SDPI has been trying to catalyze the transition to sustainable development in the country, defines as “peace, wellbeing, and social justice across generations”. Without ensuring that our habitats are free of contaminants and pollution the dream of achieving sustainable development goals would remain unfulfilled. The book in hand, “Poisons in our environment” is not merely another publication, but a diagnostic report of state of environment of our beloved homeland. The findings of Primary data collected from 38 selected sites in three provinces and Islamabad Capital territory of Pakistan reflect that dumping untreated industrial effluents; indiscriminate use of pesticides; and irresponsible dumping of pesticides are the major sources of soil and water contamination, affecting our environment. The evidences also establish that poor land use planning which allows industrial wastes to be dumped in residential areas, or allows conversion of dumping sites without their reclamation for residential and commercial use exposes human population to the above mentioned toxic wastes.

Dr Khwaja is consistent, persistent and one who pursues excellence, be it SMART program for the industry, POPs chemicals, mercury & children health or residual chemicals in environmental segments, he has a habit of trying to transform his work into a piece of excellence and one of the reflections of his efforts for perfection is the launching of this book. I have no hesitation in saying that the kind of work presented in this book has kept SDPI relevant both among grassroots & in decision making/policy making corridors. The book highlights the direly needed bridging Policy –Practice Gap, also ascertaining and recommending private sector to go green for green growth. It will be instrumental in identifying policy gaps regarding one of the most pressing environmental issues. Noting that there was no dearth of relevant laws in Pakistan, the area they need to strengthen is the capacity of regulatory bodies for better implementation of such laws.

While congratulating the author on completion of this volume, I am thankful to him for launching it on Sustainable Development Policy Institute (SDPI)'s 28th anniversary.

Dr. Vaqar Ahmed, *Joint Executive Director, SDPI, Islamabad, Pakistan*

I would join all in congratulating the author - Dr. Khwaja for this tremendous effort. At the same time I take this opportunity to also thank the reviewers for their excellent comments and inputs.

I agree with most of their encouraging feedback.

As the former Secretary, Ministry of Climate Change informed that the real work starts now i.e. getting the implementation of these recommendations initiated. In this regard, I would like to submit three more points.

First, it is important to build the capacity of our civil society organizations at the grassroots level. They would be the first to check or inform the relevant regarding these negative externalities in the society.

Second, while many turn to our judicial process to get such negative externalities noted, however this process is found slow and often things remain inconclusive. In this regard, orientation of our judiciary at all levels on matters of environment, climate change, and health is important.

Finally, the building codes and zoning laws in almost all industrial cities need to be updated and their implementation needs to be ensured. Modern building and zoning laws should contain guidelines which help prevent production processes that harm our environment and health.

The book carries a critical insight for corporate social accountability. Thanks.

SDPI Distinguished Panel

Mr. Syed Abu Ahmad Akif, *Prime Minister's Inspection Commission; Past Federal Secretary, Ministry of Climate Change, Government of Pakistan*

The book is a valuable contribution to highlighting some crucial environmental issues in Pakistan. The contents of this book need to be widely circulated for the benefit of both, the people of Pakistan as well as policymakers. (“Book Launch: Speakers term hazardous industrial waste a critical issue to be addressed urgently.” Daily Times, Islamabad, Pakistan. August 13, 2020. Video recording link:

<https://sdpi.tv/show.php?cat=other&id=1190>

Ms. YAO Linling, All-China Environment, Federation (ACEF), Beijing, China

The field survey to 38 contaminated sites provides such valuable first-hand data and the contamination map of 3 main provinces in Pakistan. Outside of Pakistan, we can even imagine how serious the health condition of the villagers is by living within, nearby these sites or the poor even relying on the waste picking. The info will help multi-stakeholders realize how urgent these should be changed for the public health and even the economic growth in Pakistan. It was most shocking to read that people even dismantle and melt batteries to extract reusable material, thanks the author, Dr. Mahmood Khwaja, for sharing all the findings, which will be important inputs for future solutions by multi-stakeholders, and this is also a precious call for more joint efforts at both domestic and global levels towards the waste management in Pakistan.

Bringing together EPA staff of the two countries, especially local EPAs, and providing capacity building on environmental policy development and implementation on EIA, waste management and hazardous sites management. Experience-sharing on management of waste management (including imported waste from other countries), as well as the management of the increasing medical waste under Covid-19;

Awareness-raising and practice-sharing between China-Pakistan industries on the waste management, through “Industrial Match-Making” for waste treatment between China and Pakistan, including: facilities and equipment for waste treatment plants especially waste water treatment system; green technology transfer on polluted site remediation of hazardous sites, imported waste management, water waste management, waste dump & contaminated soil removal soil remediation.

As an environmental NGOer, I am thinking of how civil societies could change the situation, esp. working at a Chinese environmental NGO, how China-Pakistan civil societies could work together towards this. Based on the findings in the book, with the constraint of resources, facilities and expertise in Pakistan, civil societies of Pakistan and China could be the important bridge between the two countries by reaching multi-stakeholders to facilitate the awareness raising, capacity building, experience sharing, technology transfer, etc. to put them specifically.

Awareness-raising of villagers/the public on the harm to health from hazardous exposure of the toxic waste (like waste picking, battery melting, etc) and experience-sharing on promoting. It is worth mentioning, helping the

local people out of poverty is critical and fundamental, so community development towards poverty alleviation for the local rural people are needed, by providing more living skills to help them out of the living condition of relying on the traditional and harmful waste recycle.

Dr. Lilian Corra, International Society of Doctors for Environment (ISDE), Argentina

Excellent synthesis of professional experience expressed in a tool that aims to strengthen the decision-making process to protect the health and productivity of communities. The information is organized to facilitate effective intervention actions.

The author is an excellent professional whose work goes beyond the scientific as he has dedicated his time to bring "Science to Action". Few professionals recognize the importance of correctly communicating science and engaging sustainably to promote actions (based on studies and science) to protect the environment and human health. This demands great effort, dedication and time. I recognize the author's work very well reflected in the great effort to carry out this work that is presented today. Congratulations.

Dr Roland Weber, POPs Environmental Consulting, Germany

The book "Poisons in our environment" of Dr. Mahmood Khwaja complements Pakistan's endeavour to protect human health and the environment from persistent pollutants. While the national implementation plan of Pakistan for the Stockholm Convention addresses persistent organic pollutants (POPs)¹, this book additionally investigates, describes and highlights the pollution by highly persistent inorganic major heavy metals such as arsenic, cadmium, chromium, lead, mercury and nickel from industries and waste management and disposal. This inorganic pollutants are perfectly persistent since they cannot degrade at all and consequently the sites which are contaminated by these pollutants could stay polluted for centuries and millennia and possibly "forever" in human time scales. Different to POPs, these heavy metal pollution are not addressed by international

¹ Government of Pakistan (2019) UPDATED NATIONAL IMPLEMENTATION PLAN (NIP) FOR PHASING OUT AND ELIMINATION OF POPS FROM PAKISTAN UNDER STOCKHOLM CONVENTION ARTICLE 7 (a). Ministry of Climate Change, Islamabad 12 February 2020.

convention because these pollutants do not travel across borders². Instead these pollutants largely stay at the site where they were released and can contaminate the surrounding population by exposure from water and soils and food producing animals accumulating these pollutants. Since all the heavy metals addressed in this book are very toxic and are perfectly persistent and due to their relative low migration continue keep sites contaminated, there need to be a particular high interest of a country to control these pollutants for national security and safety for current and in particular for the future generation contributing to sustainable development. The current book brings contaminated sites and their relevance for Pakistan and the affected population into the spotlight.

Therefore the book is a needed wake-up call to control these heavy metal pollution in addition to pesticide pollution and other pollution by persistent contaminants. If Pakistan is not addressing the pollution from industrial activities and the mismanagement of waste, the country will step by step get further polluted resulting in large health cost and eventually remediation cost.

The book also highlight the risk of contamination of ground water and the use of heavy metal contaminated irrigation water resulting in contaminated food crops documented also earlier (Khan et al. 2013). Climate change will result in more water shortage in Pakistan in future and consequently will increase the need of reusing waste water for irrigation with associated pollution risk. Only if heavy metals and other persistent water-soluble pollutants are controlled, the reuse of water can be sustainable. Otherwise the reuse of water could result in heavy metal exposure of Pakistan population at large.

The author of the book together with colleagues visited suspected contaminated sites in different provinces in Pakistan and did initial site assessment of the pollution and initial assessment of likely affected population. The results are alarming and require further detailed follow-up assessments at these sites and the stop of the exposure. Furthermore the study need to be extended to other contaminated sites for the protection of affected population at large.

I hope that the book will have a wide dissemination and that the government of Pakistan and the governments of the provinces will hear this wake-up call

² The only exemption is mercury, which is to some extent volatile in the elemental form and can cross borders and therefore is also addressed by an international convention – the Minamata Convention.

of Dr. Khwaja for the sake of the future generations of Pakistan. Then future generations would have a reason to praise the prudence, foresight and vision of the current generation for true sustainable development which does not compromise the ability of future generations to meet their need and to guarantee the basis to raise healthy children in a cleaner Pakistan. Thus the control of heavy metals, POPs¹ and other pollutants should become a part of Pakistan vision 2025³ and the implementation of the 2030 Agenda for Sustainable Development⁴. To understand the material and substance flows of heavy metals and other persistent pollutants and to control and reduce these pollutants to minimize the exposure of current and future generations is urgently needed *for* a bright future of Pakistan's population.

Professor Babajide I. Alo, FAS University of Lagos, Nigeria

The book is a decently written 5-chapter books and it's a compilation of studies and contributions of research in hazardous substances present in the environment in different parts of Pakistan coming from poor or absence of proper management of municipal and industrial waste including medical waste and waste streams of chemicals from industrial facilities across the tested sites in Pakistan.

It starts with an introduction that draws the reader's attention to the fact that Pakistan environmental Protection Act defines hazardous substance and hazardous waste (PEPA, 1997) and based on the same a contaminated site may be described as an area which because of its hazardous contaminants (toxic, explosive, flammable, corrosive, radioactive or other characteristics) cause or is likely to cause, directly or in combination with others matters, an adverse environmental effect. The book admirably described Key contaminants of selected polluted sites across Pakistan and it assessed and discussed. The pollutants (chemical poisons) discussed in details together with values found by robust scientific methods were mostly metals – Lead (Pb), Copper (Cu), Nickel, Mercury (Hg), Arsenic (As) and Zinc (Zn). The studies of the Key contaminants studied at the polluted sites included exposure and resulting adverse health effects. The sites studied across the nation of Pakistan included: Khyber Pakhtunkhwa Province and Islamabad (Federal Capital) - sites in Abbottabad, Nowshera and Peshawar and

³ Government of Pakistan (2014) Pakistan 2025 One Nation – One Vision. Ministry of Planning, Development and Reform.

⁴ Government of Pakistan (2019) Pakistan's Implementation of the 2030 Agenda for Sustainable Development. Voluntary National Review PAKiSTAN.

in/around Islamabad; Punjab Province - Sites in Faisalabad, Kasur, Khanewal, Lahore, Multan, Rawalpindi, Sahiwal and Sialkot; Sindh Province - Sites in Hyderabad, Tando Muhammad Khan and Karachi

The book is commended as it gives a very useful review of the considerable but very commendable earlier research and work on hazardous contaminants and polluted sites in Pakistan, especially in KPK Province And Islamabad, Punjab Province And Sindh Province. The introductory chapter also ably reviewed and provided the historical review of the Pure Earth (PE) /Former Blacksmith Institute (BSI) and Sustainable Development Policy Institute (SDPI) initial site assessment (ISA) of contaminated sites in Pakistan. The report on the Hazardous waste dumping site Salhad in Abbotabad is pathetic especially that “The continuous burning of medical waste at Salhad dumping site, was resulting into increased air pollution which was a serious threat to environment and public health, especially of the local, Havalian and Abbottabad residents.” Just like the report of the Depleted Pesticides Dump, Jamrud Road, in Peshawar. Analytical tests reports (ATRs) of the composite samples from all the sites visited and tested indicated values much higher than allowable levels in environmental media and are injurious to humans and the environment and the ecology. The pathways for human exposure to these chemical contaminants at the sites, could be either of air, water soil, food, dermal contact and via inhalation and may likely cause dental fluorosis, allergic/hypersensitivity, kidney damage, cancer, brain and bone diseases.

Conclusion: The book has eminently affirmed that Wastes management has long been an issue of critical concern, for the health sector, environmental protection agencies and civic authorities in the country. None of these bodies has the resources, the facilities or expertise to ensure the environmentally sound waste management. Legacy toxic pollution resulting from hazardous waste sites, is rapidly on the increase, damaging the environment as well as threatening the public health, especially, the health of the vulnerable population. The completed initial site assessment of 38 sites, described and discussed in the book have also indicated growing significant risk, both to the environment & health of the people in general and those living in the near vicinity and around the investigated sites in particular. It's well established that public health in more than one way, ultimately impacts the Pakistani national economy. The author has therefore recommended some initial interventions, as required and feasible for the site and these include active site controls and treatment, clean up, treatment plant installation, alternate water supply for drinking/domestic needs of the local population, introduction & promotion of

water treatment system (including households water treatment), waste dump & contaminated soil removal, soil remediation around the site, training & awareness raising and development, implementation of specific legislation for hazardous sites and further research, as may be required.

Finally, the author Dr Mahmood Khwaja must be highly commended and has done and or coordinated an excellent series of studies on hazardous substances in Pakistan environment and provided a treatise on the state, risks and impacts of chemical and waste hazardous substances in Pakistan and raised issues of chemicals of concern that must attract the attention of Pakistan's environmental protection institutions and governance.

Dr. Joeph DiGangi, Senior Science Technical Adviser, International Pollutants Elimination Network IPEN, (presently) South Korea,

Thank you very much for your invitation and congratulations to Dr. Khwaja on the publication of this book. Thanks also to the extensive work by colleagues at the Sustainable Development Policy Institute (SDPI). "Poisons in Our Environment" provides a comprehensive review of data on a large number of contaminated sites in Pakistan. Identification and characterization of contaminated sites is a fundamental step toward protecting communities and the environment from the harmful effects of toxic metals and chemicals. It is also key to sustainable development – including fulfillment of Sustainable Development Goals 3 (health), 6 (water and sanitation), 9 (sustainable industrialization), 11 (sustainable cities), 12 (sustainable consumption and production) and 15 (reverse land degradation).

The book describes the location of each site along with information about how it became contaminated. Many sites are close to residential areas and some of them are used as playgrounds by children. The contamination sources included textile factories, tanneries, and paper mills, among many others. Interestingly, owners of the tanning factories lived comfortably far away in big cities and were not concerned about environmental and public health problems, due to pollution from their facilities.

The SDPI team tested samples of soil and water for a variety of metals, but it is likely that many other substances are present at these sites including chemicals used in dyes, fat liquoring agents, pharmaceuticals and others. The testing data is useful but the testimonies of nearby residents are equally important. These comments form an important part of the data that is presented. These local observations can be very important in terms of assessing community health impacts. For example, at the Bangla Kamboyan

site in the Kasur district, a health professional said, “Most of the females coming to the Delivery Home for treatment were anemic, suffer malnourishment with complaints of abdominal discomfort, Hepatitis C and abnormal births.” These kinds of observations should raise serious public health concerns.

In addition to endangering public health, contaminated sites from one industry can harm other industries and even damage infrastructure. For example, the Chenab drain in Punjab Province damaged roads and corroded and damaged the railway track. At the Jaranwala Road site, the area around the site could no longer grow crops. The use of contaminated water for irrigation appeared to be common, damaging agriculture. One of the most sobering comments that appeared repeatedly in the book is this one: “No efforts/initiatives seemed to have been made by any relevant stakeholders, with regard to environmentally safe management of the effluents/waste water, released from industrial units near the site area.” Some people would understandably find this depressing. However, it should be viewed as a call to action. Many of the environment agency and industry representatives quoted in the book point to the need for effluent treatment before discharge. This is a critical step before remediation begins, because the constant flow of contaminants needs to be turned off. In fact, the ultimate goal for these industries should be zero discharge.

Identification, management, and sustainable cleanup of contaminated sites is a key part of chemical safety. Sites that present the most risk to human health and the environment should be prioritized for remediation. A remediation plan should identify stakeholders and responsibilities; develop goals and cleanup criteria; determine preferred options for remediation; document the remediation methodology; develop an environmental management plan; and define a validation program to demonstrate a successful cleanup. Addressing discharge and remediation are the first steps but the industries should not stop there. They should work diligently to reduce and eliminate toxic substances in their manufacturing processes instead of generating a toxic mess that needs to be cleaned up later. Many people find the topic of contaminated sites to be overwhelming. However, identification and characterization of contaminated sites is a key step toward health and environmental protection. That is why so many public interest NGOs around the world, including many in the IPEN network, work on this issue.

Congratulations once again to Dr. Khwaja and SDPI and best wishes in moving these and other chemical safety issues forward. Thank you very much.

Dr. Darryl Luscombe, *Consultant Hazardous Chemicals Issues, Canada*

Providing an assessment of contaminated and hazardous waste sites in Khyber Pakhtunkhwa Province and Islamabad, as well as the Punjab and Sindh Provinces, this document presents the investigations of the SDPI initial site assessment team.

Dr Khwaja and his team provide detailed background information and laboratory testing results for a range of toxic heavy metals and pesticides in water and soil samples collected from the sites. Importantly, SDPI also report on the sources of the toxic wastes and the likely impacts of the sites on local people, including children and pregnant women, the most vulnerable populations to the threats posed by these toxic chemicals.

Dr. Khwaja provides a clear list of priorities for further work and urgent calls for action for the sites posing the most severe risks to human health and the environment. I would urge Government authorities and industry to take heed of these findings and act to ensure the protection of the most vulnerable in society, as a matter of urgency.

Dr. Yuyun Ismawati Drwiega, *Senior Advisor & Co-founder Nexus3, Indonesia*

I've read the draft. The book presents the most comprehensive information about toxic hotspots in Pakistan, covering all areas. Somehow I remember that a couple of years ago you collected samples from a river in the Gilgit Baltistan area where you could find the gold washers using mercury. I couldn't see any results of that sampling in the report or maybe I missed it.

For the way forward, lessons learned from any remediation case in Pakistan can be highlighted.

And perhaps there should be a way or mechanism for community monitoring and reporting?

That way any pollution occurrence can be quickly reported to the relevant agencies or can be uploaded to a social media platform.

Lastly, it will be good to promote citizen science and invite more youth to monitor environmental pollution.

Dr. Jindrich Petrlik, *Executive Director, Arnica-Toxics, Czech Republic*

The review/comments via recorded video shared with SDPI accessible link given below

Video recording link:

<https://sdpi.tv/show.php?cat=other&id=1190> were shared via video accessible at:

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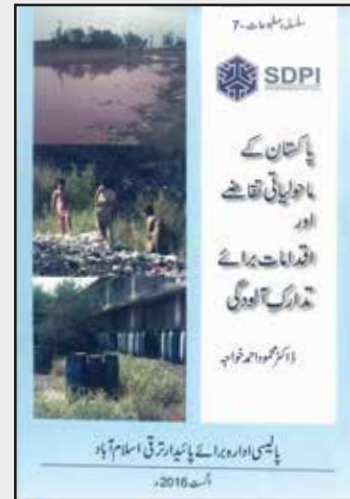
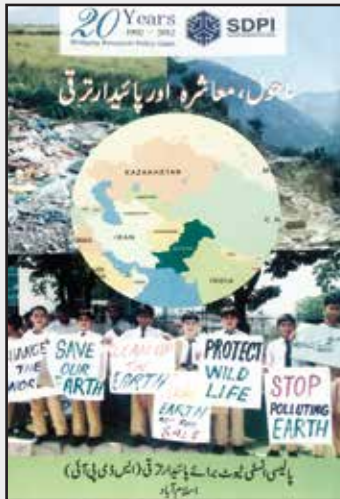
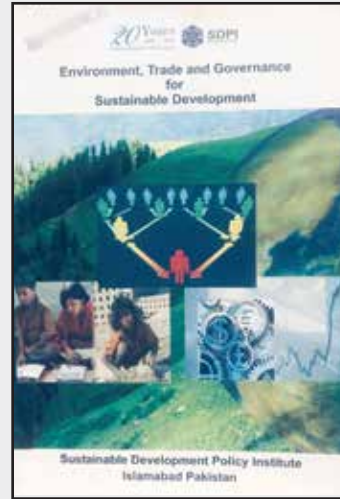
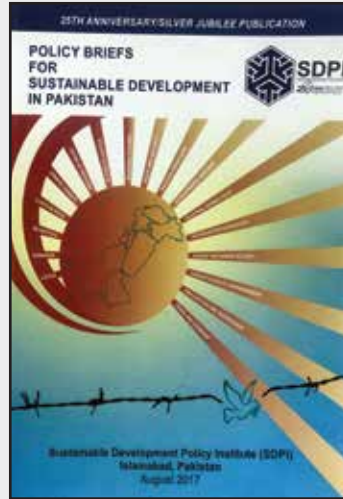
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