



# Environmental Health Assessment in Sulaymaniyah City and Vicinity

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**Sulaymaniyah, Iraq**

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## **Executive Summary**

There are many physical, chemical and biological agents either naturally present or produced by human activity that can be hazardous for human health. The urban centers of Iraq, including Sulaymaniyah, that have emerged from decades of war and poor services are suffering from an accumulation of a variety of these environmental risks generated by the population, urban services and industrial and agricultural activities. Environmental pollution in and around Sulaymaniyah city is caused by several factors including untreated wastewater, contaminated agricultural fields, untreated solid waste, industrial waste and contamination of Tanjaro River and Darbandikhan Lake from these sources of pollution.

Populations, especially those living closer to the above-mentioned pollution sources are at risk of both short and long-term effects of biological, physical and chemical contaminants, including water and foodborne diseases, heavy metals poisonings and other potentially toxic elements and compounds present in the air, water, soil and plants, especially south of the city and around Tanjaro River and Darbandikhan Lake. Neglecting these problems means that buildup of contaminants in the environment and endangering population health will continue. Generally, there is lack of necessary policies, regulations and guidelines in all sectors and at all levels in relation to safe and environmental-friendly operations in agriculture, industry, energy, and public services.

Monitoring and responding to environmental health hazards requires collaborative efforts of relevant departments, professional institutions, NGOs, community-based organizations and affected populations. Environmental health promotion also requires fighting corruption to ensure that the public interest is respected and that relevant policies, regulations and guidelines are followed and enforced. To reduce risk of water-borne diseases, strengthening water management in relation to maintaining quality, and observing regular schedules and equitable supply to all residents of the city could be an immediate solution, along with necessary infrastructural developments. The ultimate solution to wastewater pollution is establishment of sewerage treatment plants. At the same time, surveying all the sewerage channels and networks using GIS mapping is another essential organizational undertaking.

Solid waste is a major problem and the ultimate solution is recycling; while this is being under consideration, the establishment of a controlled landfill in an area that is much farther from the river is probably the most appropriate immediate solution to the solid waste disposal problem for Sulaymaniyah City. Immediate measures need to be taken to prevent further pollution of the Tanjaro River, by isolating the polluting sources. Industrial activities need to be regulated and monitored in terms of environmental and occupational safety operations and standards. Using Sulaymaniyah wastewater for farming must be prohibited by law and enforced. Quality control of locally produced and imported food stuffs and agricultural products should be strengthened. Protection of Darbandikhan Lake from major sources of pollution should be made a higher priority and measures should be taken as soon as possible to isolate and minimize major pollutants. There is also a need for extensive research and the establishment of sustained research systems on population health and environmental pollutants, especially in relation to the food chain, and the Tanjaro River, Darbandikhan Lake and air pollution.

If urgent consideration is not given to the above areas and problems, the situation may get considerably worse in the coming years, while buildup of pollutants in the environment, the food chain and in the human body continues.

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- Kurdistan Institution for Strategic Studies and Scientific Research
- Sulaimani Polytechnic University
- The William Joiner Institute for the Study of War and Social Consequences
- Chamber of Commerce and Industry
- Darbandikhan Lake Management
- Department of Environment
- Sulaymaniyah Municipality/ Departments of liquid and solid waste management
- Directorate of Agriculture
- Directorate of Industry
- Directorate of Statistics
- Directorate of Water
- Iraq Nature (NGO)
- The Health Department
- Factories and solid waste disposal companies contacted

## List of Acronyms

CoC	Chamber of Commerce
Ca	Calcium
Cd	Cadmium
Cu	Copper
DAP	A type of mixed fertilizer
Donum	A land measure used in Kurdistan equal to 2500 square meters
DoS	Department of Statistics
Fe	Iron
GIS	Geographic Information System
GRP	Glass-Reinforced Plastics
H <sub>2</sub> S	Hydrogen Sulfide
IDI	In-Depth Interview
IDPs	Internally Displaced Persons
IREX	The International Research and Exchange Board
K	Potassium
KII	Key Informant Interview
KISSR	Kurdistan Institution for Strategic Studies and Scientific Research
KRG	Kurdistan Regional Government
KRSO	Kurdistan Region Statistical Office
Mg	Magnesium
Mn	Manganese
NGO	Non-Governmental Organization
Na	Sodium
Ni	Nickel
OR	Odds Ratio
Pb	Lead
PPE	Personal Protective Equipment
PVC	Polyvinylchloride
SD	Standard Deviation
SGV	Soil Guideline Values
SPU	Sulaimani Polytechnic University
WJI	William Joiner Institute
UMASS Boston	University of Massachusetts-Boston
WHO	World Health Organization
Zn	Zinc



## 1. Introduction

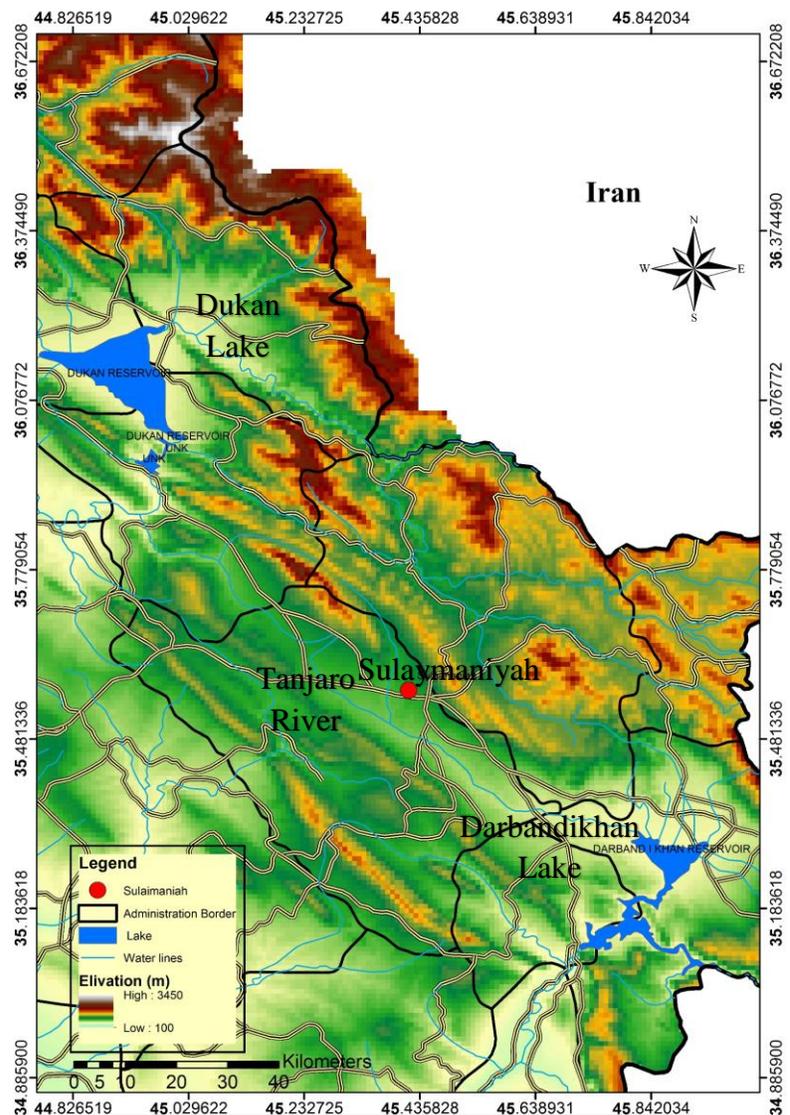
There are many physical, chemical and biological agents either naturally present or produced by human activity that can be hazardous for human health. Rapidly expanding urban populations without proper plans and organized services are especially at risk of the hazardous effects of these agents produced in excess and not safely disposed. The urban centers of Iraq that have emerged from decades of war and poor services are suffering from the accumulation of a variety of these environmental risks generated by the population, urban services and industrial and agricultural activities. The WHO reports that out of 102 diseases reported from the country of Iraq, 85 are related to environmental health and that 25% of childhood deaths are related to preventable water-related diseases[1]. Access to safe water is approximately 50%, access to improved sanitation is round 70% and there are no sewerage treatment plants outside of the city of Baghdad with 50% of waste water directly flowing into natural waterways [1].

The situation in Kurdistan may be a little better than average for the country in terms of development indicators including access to safe water and sanitation, but the same environmental problems exist. The Kurdistan Region of Iraq has an estimated population of 5.6 million, with approximately 80% living in urban areas. According to the Statistics Office, in 2012 around 97% of the population had access to safe drinking water and improved sanitation [2]. However, the situation has likely deteriorated since then due to government budget cuts and economic recessions in recent years; solid waste is still dumped outside the major cities and there are no treatment plants for wastewater. According to the same source in 2011, poverty prevalence was 3.5%, literacy in young people (15-24 years old) was 90% (males 94%, females 85). Infant mortality was 28 per 1000 live births, under 5 mortality was 32 per 1000 in 2011, moderate and severe underweight was 6.7% and moderate and severe stunting was 21% [2].

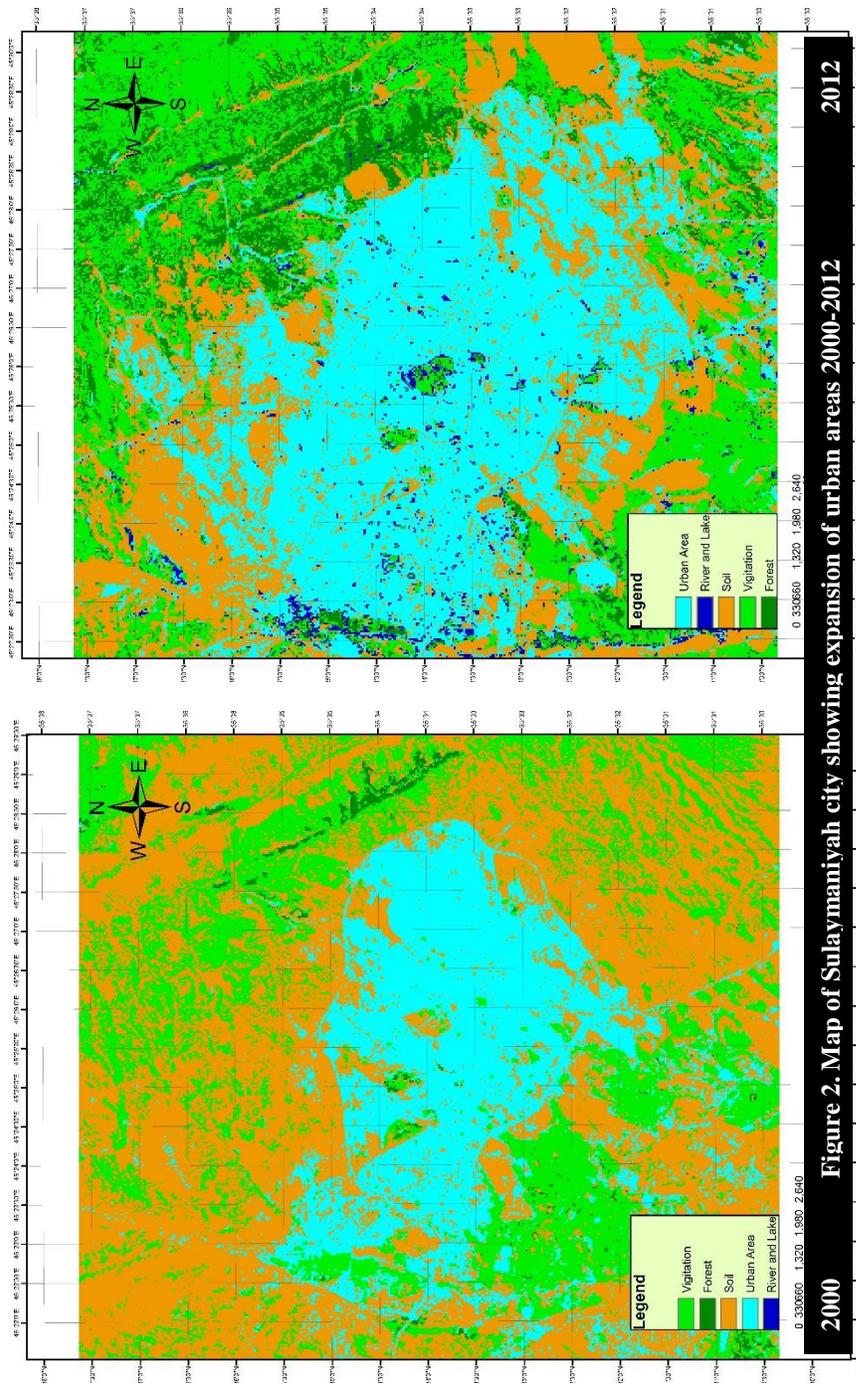
In relation to economic activity, over 50% of the employed population work in the public sector, and the vast majority of the labor force work in the service sector (76%), followed by industrial activities (18%) and agriculture (6%) [2]. In 2014, there were 89 big industrial enterprises, 182 medium and around 10,400 small enterprises in the region. In terms of

agricultural indicators, the arable area of Kurdistan region is estimated at around 1.65 million hectares, forest area around 1 million, wheat planted areas about 800,000 hectares and areas planted with summer crops was around 60,000 hectares [3].

Sulaymaniyah city is one of the 3 major urban cities of Kurdistan Region with an estimated population of around 1 million people. The city is located approximately 370 kilometres north-east of Baghdad at coordinates 35.557, 45.443. The city is located in a valley at the foot of Goizha Mountain stretching over an area of around 470 km<sup>2</sup> and extending southwards to the lower lands surrounding Tanjaro River. Topography of the city is hilly and steep making the southern parts of the city at risk of floods and pollution more than higher parts. The city has seen tremendous but poorly planned residential expansion during the past 2 decades (especially after 2003), stretching its boundaries in all directions and putting pressure on many public services including water, sanitation, health, education and transportation facilities. The city sewerage flows down to Tanjaro River south of the city. The solid waste is dumped



**Figure 1. Map of Sulaymaniyah governorate**



**Figure 2. Map of Sulaymaniyah city showing expansion of urban areas 2000-2012**

without treatment near the same river and partially covered with earth. Hundreds of small and some large industrial areas are established around the river and the river flows to Darbandikhan Lake causing its contamination as well.

There was historically one industrial area southwest of the city, but with the post-2003 boom of economy, a large number of small and medium industrial projects were initiated and a new area was allocated for these activities south of the city by the Tanjaro River. This slowly became the center of all

kinds of industrial and private sector activities. As a consequence of the industrial expansion in this area, many workers and their families moved to the area causing a considerable increase in the population of these sub-urban areas. Many internally displaced people working in the area also settled there. Thus, these southern outskirts of the city are at higher

risk of environmental hazards from industrial activities, urban waste and pollution of the river.

Despite its importance, environmental health research remains scarce in the region. There have been a few studies on water pollution around the city and on the impact of Sulaymaniyah wastewater on contamination of water and soil around and in the Tanjaro River, including the reporting of high levels of some heavy metals in the soil and water samples [4-6]. There have also been reports on contamination of Darbandikhan Lake indicating high heavy metal content of the lake water [7]. Pollution of the environment around the city from solid and liquid waste has also been subject of several newspaper articles [8, 9].

Despite the fact that successive wars, rapid urbanization and the poorly planned expansion of the major cities and industrial areas have contributed to increased health risks in the environment, these problems have not been sufficiently appreciated and researched. Air pollution, water pollution, industrial hazards, heavy metals, risks from urban solid and liquid waste, and other general physical, chemical and biological hazards are topic areas that need sustained and organized research efforts. More research on all of these environmental and occupational hazards is urgently needed. Research findings are crucial to provide evidence for action and strong arguments to advocate for healthy and environment-friendly public policies and regulations. The current environmental health assessment and capacity-building project could help initiate work in this direction.

## **2. Aims and objectives of the project and the study**

The current project supported by IREX aimed to contribute to fill the gap in environmental health research in Iraqi Kurdistan by developing an institutional capacity to respond to environmental health issues and to undertake a rapid assessment of the environmental health hazards in and around Sulaymaniyah city. The specific objectives of the project were to:

1. Develop sustainable collaboration with a US institution for environmental health research.
2. Build the local capacity at the higher education institutions in relation to environmental health research.
3. Establish at least one team of researchers at SPU/Kurdistan Institution to continue working on environmental health research.
4. Undertake a rapid assessment of the environmental health hazards around the city of Sulaymaniyah and Tanjaro River.

The current document reports on the results of the rapid assessment study which was undertaken during the October 2016-January 2017 time period as part of the project to achieve the following objectives:

1. Assess the environmental health situation in relation to solid waste disposal and possible risks to the population
2. Assess the environmental health situation in relation to liquid waste disposal and possible risks to the population
3. Assess the environmental health situation in relation to industrial activities and possible risks to the population
4. Assess the farming practices around the city and possible risks to the population
5. Assess the sources of pollution to Tanjaro River and possible risks to the population

### 3. Methodology

The environmental assessment was undertaken during the period from October 2016 to January 2017 using a variety of research methods including desk reviews, site observation visits using checklists, key informant interviews (KII), in-depth interviews (IDI) and quantitative estimation and analysis of soil and plant samples for relevant contaminants. This combination of qualitative and quantitative methods allowed for a more detailed, objective and in-depth understanding of the situation from different perspectives, viewpoints, and data sources. Design of data collection instruments, sampling strategy, training of the environmental assessment team and the pretesting of data collection instruments were carried out in primarily during the month of September and in early October 2016.

Initially a consultation meeting was organized on October 2<sup>nd</sup>, 2016 with relevant stakeholders including relevant departments/ sections of water, solid waste and liquid waste in the municipality of Sulaymaniyah, Department of Health, Department of Environment, Chamber of Industry, Directorate of Water, and NGOs and others.



#### 3.1 Desk review

A literature search was done manually for articles on environmental health hazards, water quality and water pollution in Sulaymaniyah city and on pollution of Tanjaro River. Online search was done through Google and PubMed for key words such “Pollution”, “Tanjaro River”, “Environmental Health”, combined with “Sulaymaniyah”. A PubMed search was done separately to retrieve relevant literature on environmental health hazards in other countries related to the themes of the current study.

### 3.2 Observation

Observation visits were undertaken by the research team members for different sites using a checklist guide to record objective information observed at the sites and about possible risks to human health. The sites were selected in relation to waste water disposal, solid waste disposal, farming, and industrial activities. Observation visits were undertaken to the following sites in and around Sulaymaniyah City using observations checklist guides:

- 1- Solid waste disposal area (near Tanjaro River)
- 2- Wastewater disposal area (channels from the city to the Tanjaro River)
- 3- Farms near solid waste disposal area
- 4- Farms near wastewater disposal area
- 5- Factories near Tanjaro River

### 3.3 Key informant interviews

Key knowledgeable officials and professionals working in areas related to the theme of the study were interviewed in-depth to gather information on specific aspects of the situation, services and policies/standards available in the area. Semi-structured questionnaires specifically prepared for each interview were used to guide the interviewer obtain the relevant information that was available with the informant. Fifteen such KIIs were undertaken as shown in table 1:

<b>Table 1. Key informant interviews</b>		
	<b>Persons/position</b>	<b>Number</b>
1	Chamber of Commerce and Industry	1
2	Darbandikhan Lake Management	1
3	Department of Environment	1
4	Department of liquid waste management	1
5	Department of solid waste management	1
6	Directorate of Agriculture	1
7	Directorate of Industry	1
8	Directorate of Statistics	1
9	Directorate of Water	1
10	Factory manager	1
11	Iraq Nature (NGO)	1
12	Monitor of solid waste disposal site	1
13	Preventive health professional	1
14	Solid waste disposal Company	1
15	Official on fuel distribution	1
	<b>Total</b>	<b>15</b>

### 3.4 In-depth interviews

Citizens, workers and farmers living in and around the city and Tanjaro River were interviewed to assess their knowledge, attitudes and behaviors about environmental hazards and activities they might be exposed to. Semi-structured questionnaires specifically prepared for each purpose, were used to guide the researcher undertake the interview. Thirty such IDIs were undertaken as shown in table 2 using the specific guide for each interview:

	<b>Category</b>	<b>Subcategory</b>	<b>Sample</b>	<b>Number</b>
1	Sulaymaniyah city	Resident	Males	4
			Females	4
2	Suburban-Tanjaro industrial area	Resident	Males	2
			Females	2
		Factory worker	Male/female	4
3	Farmer near Tanjaro industrial area and river	Farmer	Males	4
			Females	4
4	Darbandikhan Lake	Resident	Males	2
			Females	2
		Fisherman	Males	2
	<b>Total IDIs</b>			<b>30</b>

Separate IDI question guides were used for the following categories:

- 1- Residents of Sulaymaniyah
- 2- Suburban Tanjaro residents
- 3- Residents of Darbandikhan
- 4- Farmers near Tanjaro
- 5- Factory workers
- 6- Fishermen

### 3.5 Soil and plant samples

Six samples from soil at the banks of Tanjaro River near the solid waste disposal site of Sulaymaniyah city and 4 samples from plants in the same area were taken for laboratory analysis using standard testing preparations, digestion and assay methods for trace elements.

## 4. Findings and Discussion

### 4.1 The context

According to officials from the Directorate of Statistics (DoS), the population of Sulaymaniyah governorate including Halabja and Garman areas is estimated at 2,210,708 and that of Sulaymaniyah city is estimated at about 907,000 in 2017. It should be mentioned, however, that there has been no census in the Kurdistan region of Iraq since 1987, and these figures are extrapolations from estimated population figures used during the Oil-for-Food program in the late 1990s. Sulaymaniyah governorate spans over an area of 21,000 km<sup>2</sup> while the city stretches over an area of 470 km<sup>2</sup>. The city has seen an unprecedented expansion of population settlements during the past 10 years, for example in 2009 there were 113 neighborhoods but in 2014 they increased to 162. The average family size in Sulaymaniyah is 4.7 and the governorate has a relatively young population with around 50% of the population being below 22 years of age. According to the same source, the annual population growth rate is 3%. Temperature fluctuations in Sulaymaniyah are extreme, ranging from as low as -8 Celsius in the winter to as high as close to 50 Celsius in the summer. The rainy season usually starts from October and continues until early May with a variable amount of rainfall, sometimes as high as 900 mm such as occurred in the 2015-2016 rainy years and sometimes as low as 300 mm in drought years; but the average annual rainfall would be around 600 mm per year.

The DoS does not collect and store information on activities related to environmental pollution such as number of cars, types and amount of fuel used, number of factories, generators, and amount of green areas in the city. However, even the existing data is not adequately used for planning, “it is sad that we only collect data and send it to Kurdistan Region Statistics Organization and the Ministry of Planning, without utilizing these data ourselves, and we do not use our information and data for planning and that is why environmental pollution will continue to increase.”

In the view of the DoS, the biggest problems in relation to Sulaymaniyah environment are untreated solid and liquid waste, hospital waste which is largely not sterilized or incinerated but disposed with municipal waste, waste of factories and cars, all of which contaminate the

air, soil and water around Sulaymaniyah. The concern is clear expressed with a tone of helplessness “Sulaymaniyah environment is really polluted and we are in danger. It’s a big problem but who cares or pays attention?”

This concern was also reiterated by the public health professional we interviewed who said “we know generally the environment has been polluted by several sources such as cars, factory smoke, medical waste, and others kinds of waste which is not properly disposed.” These unresolved problems are globally known to have immediate and long-term impact on the health of populations, and in Sulaymaniyah too, as the professional stated that “several disease are related to these environmental hazards such as asthma, typhoid, diarrhea and cholera which occur repeatedly. Contamination of water and food and failure to properly treat the city’s wastewater which sometimes mixes with drinking water are responsible for some of these infectious diseases.”

Environmental health protection is a collective effort by relevant governmental authorities, industry, non-governmental agencies and the resident population. However, existence of regulatory and monitoring bodies and public health-specific agencies are essential to lead the effort. The department of health currently does not have a section to monitor and promote environmental health in the city. According to the health professional interviewed, in the past “there was a section called environmental health but this section was closed several years ago, and the mandate was given to the Board of Environment.” The Board of Environment has departments in major cities including Sulaymaniyah. However, they currently do not seem to have the sufficient capacities and professional expertise in relation to environmental health to monitor environmental risks and lead environmental protection efforts. Lack of emphases on environmental issues in the department of health has also led to scarcity of research on sources of pollution, environmental risks and health problems that could be related to acute and chronic environmental exposures.

Instead of the environmental section, the department of health has created an infection control section mainly to ensure that proper infection control procedures are undertaken in hospitals to prevent occurrence and spread of infectious diseases. However, even this section “is not as effective as required; it does not work to prevent infections but when the infection

occurs and the epidemic curve reaches the peak with morbidity and mortality, only then do they start responding.” Effective infection control systems require not only proper training of staff, equipment (gloves, disinfectant, etc.), and written standard protocols and procedures, but also a properly functioning surveillance and reporting system to quickly detect new infections and any changes in current trends to ensure effectiveness and rapid response. Several outbreaks of cholera happened during recent years, the last being in 2014, but these were not properly investigated to identify the source. The implications of consuming contaminated water or wastewater-irrigated vegetables as the cause of these outbreaks remains a high probability.

The Department of Environment that serves as the arm of the Board of Environment in Sulaymaniyah City, is in charge of issues relevant to protection and preservation of the environment, including aspects related to environmental health. According to them the main environmental pollution problems in the city are the factories, the solid waste, and the wastewater, as well the increasing number of motor vehicles in the city. They acknowledge the absence of major regional guidelines on environmental protection, environmental friendly policies and ways of avoiding and mitigating environmental health risks. There are only simple instructions on certain specific environmental issues at the departmental level. Even in areas where such instructions exist, their enforcement is weak and not properly implemented. Although they have good lab facilities for testing water, soil and air, there is a shortage of professionals, lack of regional polices and guidelines and the current financial crisis, all of which have limited their capacity to deal with the huge challenges of environmental protection in the governorate. According to the director, their main duties are now restricted, “we only identify the problems and report them to the ministry; we cannot do anything to solve those problems because they are not related to us but to other ministries; for example garbage disposal is related to the Municipality. We also have some monitors for the factories to monitor toxic emissions from factories.”

#### **4.2 Soil and plant samples**

Table 3 shows results of analysis of 10 samples where components are presented as means of total concentrations of the base elements in agricultural soil and plants at the study area. Base

elements such as Sodium (Na), Potassium (K), Magnesium (Mg) and Cadmium (Ca), are crucial elements for plant nutrition. They are occasionally found in plants in high concentrations because of their essentiality and since agricultural plants, under optimal production conditions, would absorb a considerable amount of these metals.

**Table 3. Results of soil and plant samples near Tanjaro River and Sulaymaniyah City solid waste disposal area analyzed for a number of elements (mg/kg)**

Soil Samples	Na	Mg	K	Ca	Ni	Cu	Zn	Cd	Pb
Tanjaro 1	2152	12617	7843	104887	98.5	31.6	105.9	2.37	22.9
Tanjaro 2	2210	11608	6043	129461	86.9	29.6	170.5	4.33	58.9
Tanjaro 3	2350	13622	7377	100422	104.4	35.2	422.4	3.37	22.1
Tanjaro 4	2842	13952	7636	102358	109.3	31.2	110.8	9.29	60.7
Tanjaro 5	2915	13848	7546	102624	107.9	28.9	76.7	6.23	18.7
Tanjaro 6	1987	11821	6934	121405	91.9	32.7	403.8	1.48	63.3
<b>Mean</b>	<b>2409</b>	<b>12911</b>	<b>7229</b>	<b>110192</b>	<b>99.8</b>	<b>31.5</b>	<b>215</b>	<b>4.51</b>	<b>41.1</b>
<b>SGV</b>					<b>100</b>	<b>100</b>	<b>300</b>	<b>1.8</b>	<b>100</b>
<b>Plan Samples</b>									
Turnip leaf1	747	277	2389	1187	0.078	0.074	1.58	0.018	0.014
Turnip leaf	209	115	1139	445	0.059	0.043	0.835	0.013	0.090
Turnip Bulb1	190	148	4787	1063	1.90	0.244	0.255	0.029	0.047
Turnip Bulb1	561	254	4830	714	0.366	0.173	2.69	0.015	0.0029

In general, the order observed for the mean concentrations of major elements in soil samples was  $Ca > Mg > K > Na$ . The concentrations are higher if compared to the other trace elements in the plant and soil because of the essentiality of these elements for living organisms.

The mean values of trace elements in agricultural soils are also given in Table 3, they arranged in the followed decreasing order:  $Ni > Cu > Zn > Pb > Cd$ . The results showed that the mean concentrations of trace elements in the soil samples at the different study areas were all below the Soil Guidance Values (SGV) except for Cadmium that was considerably higher than the standard values. Some samples had slightly higher content of Ni. The mean cadmium content of all soil samples was almost 3 times the standard value (4.51 mg vs. 1.8 mg). All samples were taken from soil of fields close to the solid waste pile (within 50 meters). There can be little doubt that the source of the Cd contamination is the solid waste and the waste components implicated could be nickel-cadmium batteries, cadmium-

pigmented products (plastics, ceramics, and glasses), polyvinylchloride (PVC) products, cadmium-coated alloys and electronic boards.

A significant amount of trace elements were also found in plant tissues indicating availability of trace elements in the area and suggesting that input trace elements in the soil are more labile and able to be transferred from soil to plants consequently posing adverse effect to human health.

### 4.3 Characteristics of the Study Respondents

A total of 15 key informant interviews with relevant officials and 30 in-depth interviews with citizens as shown in table 2 were conducted. To have an indicator of respondents general feeling of being protected from environmental hazards, we included a question for each study participant to rate their feeling of being protected “On a scale of 10 where 10 is feeling completely protected and zero is not feeling protected at all, how much do you think you are protected from environmental health risks in general, not only related to your work?”.

The analysis of the main characteristics of the respondents and the scores for the above question are presented in Table 4. In total, there were 45 interviews in the study (15 KII and 30 IDI). Of these 44 answered the rating question. The age of participants ranged from 23-56 years with a mean age of 36.2 years (SD 8.8). All KII but one were males while 67% of IDIs were male. The score ranged from 0-9 with a mean score for feeling protected from environmental hazards was 3.83 (SD 0.38) out of 10. The score was not significantly different between IDI and KIIs (KII 3.1, IDI 3.7,  $p=0.62$ ) or between males and females (male 3.92, female 3.46,  $p=0.67$ ).

**Table 4. Main characteristics of participants**

	All	KII	IDI
	Number (%)	Number (%)	Number (%)
All	45 (100%)	15(33%)	30(67%)
Male	34(76%)	14(93%)	20 (67%)
Female	11(24%)	1 (7%)	10 (33%)
Age in years, mean (SD)	36.2 (8.8)	-	-
Mean score for feeling protected (SD)	3.83 (0.38)	4.1 (0.57)	3.7 (0.49)

The low score indicates that all participants irrespective of gender and role were highly concerned about the environment and considered themselves poorly protected from environmental health hazards. While this concern indicates that most respondents consider the environment not to be healthy and that their lives are at risk of environmental hazards, it also indicates an awareness about the problem which could be a positive factor for future programs to address the problem.

#### **4.4 Drinking water and associated health hazards**

The main sources of Sulaymaniyah drinking water are Dukan Lake (two pipe lines: project 1 and project 2), Sarchinar ground water and a few small sources in the city. Some peripheral neighborhoods lack piping and are still supplied through tankers. Transport of water from source to the city is done using GRP (Glass Fiber Reinforced Plastics), steel and iron pipes all of which are permitted under global practices. The city water network is mainly composed of polyethylene pipes. The network has been continuously renewed and repaired. According to the department of water, mixing of wastewater with the drinking water network is still a problem although rare compared to the past and happens 4-5 times a year. For example the neighborhoods of Bakhan and Khalifawa are suffering from repeated pollution of the drinking water. Otherwise, the quality of water is generally acceptable in terms of physiochemical and biological properties as reported by a study analyzing over 2000 samples collected and analyzed throughout 2014 [10]. It should be noted that the Dukan Lake water is filtrated before being chlorinated and piped to the city. Sarchinar water is spring water and thus it is only chlorinated. However there are concerns about pollution of this source by pollutants from humans, birds and the air because it is not properly covered and protected but only surrounded by fencing.

The Directorate of Water regularly checks the quality of water to make sure clean water is delivered to the homes. Samples are collected and checked at source before filtration, after filtration, in the storage tanks and at the beneficiary level. The water is tested for usual ingredients but not for mercury, iron, barium, lead and arsenic—that are also potential risks for human health on the long run.

One of the problems of the water supply that is also a concern for the population is the yellow tint of the water in certain times of the year. According to the water official, “this mainly occurs in autumn and spring when rains and flooding stirs the lakebed causing suspension of the residues containing high levels of H<sub>2</sub>S with yellow tint and bad odor. Contamination of the lake water with wastewater from the towns on the lake and the feeding rives also contributes to this problem.”

Although the quality of water generally seems fine, irregular, interrupted and insufficient water supply to households is common and could compromise cleanliness of water at the household level. Households are generally provided with 4 hours running water per week. Therefore, families are all obliged to store water in over-roof tanks. Obviously this does not always meet the recommended daily requirements as recommended by KRG which is 320 liter per capita per day. This sort of supply is associated with higher health risks thorough increased probability of contamination at the household level. As optimal access to water and to lower health risks, the WHO recommends continuous supply through taps of at least 100 liter per capita per day[11]. In areas where interruption is more severe, families may be obliged to use other sources such as sharing shallow wells and buying from tankers while quality of such water could not be guaranteed. Several outbreaks of cholera happened during the recent years, the last being in 2014, but these were not properly investigated to identify the source. Consuming contaminated water as the cause of these outbreaks remains a probability. One preventive measure by the water authorities at times of these outbreaks is to strengthen the chlorination of water from the usual 1 ppm to 2.5 ppm.

The principal microbiological contaminants of concern to human health in drinking water are those derived from feces of humans, animals and birds. Pathogenic bacteria, viruses, protozoa and helminthes could be transmitted to humans through ingestion of water contaminated with such sources. Major water-borne pathogens are those causing diarrhea, dysentery, cholera, typhoid, hepatitis A, amoebaiasis, giardiasis and helminthic infestations. Mitigating microbiological contamination of water requires multiple steps at different levels to protect the source, the distribution system and the point of collection and delivery[12]. Contamination of rivers and agricultural fields with the untreated wastewater in the

Sulaymaniyah governorate exposes the population to all those risks in varying degrees. Populations around Tanjaro River could be at a higher risk because of their vicinity to the polluted river and agricultural fields, and waste dump sites and sewerage channels. Populations supplied by water from Darbandikhan Lake could also be at a higher risk because the polluted surface water is piped to houses without proper treatment.

All the eight residents of Sulaymaniyah City that we interviewed were using tap water in their homes for washing and cooking, and mostly for drinking, except two participants who said they were using bottled water for drinking. The four main themes which emerged from the interviews about drinking water in Sulaymaniyah City were: (1) General satisfaction about water supply; (2) Interrupted supply (water open once 3-5 days and only for a few hours each time) and hence the need for storage in overhead and other tanks; (3) The presence of yellow tint to the water, –especially in autumn; and (4) An odor and taste of chlorine. One participant said they sometimes need to buy water from tankers and they were not sure about the source therefore they added chlorine. The interrupted supply could be the main concern in relation to health, especially when it lasts longer and people run out of water they have stored. In such conditions buying from private tankers may be indispensable, while neither the source nor the transportation are always clean. Many tankers are locally made tanks trailed by tractors which are also used to supply water to construction sites. These tankers could be contaminated as we have observed them taking water from Tanjaro River for constructions and industrial purposes. The unprecedented expansion of the city due to population growth and economic development, both in terms of residential areas and industrial and commercial activities has greatly increased demand for water, and the water authorities have not been able to keep up pace with the increased demand, especially during the past few years. It is expected that the situation will get even worse in the coming years, while the demand continues to increase and the financial crisis does not allow for expansion of water networks and probably not even for the proper maintenance of the water supply system. Strengthening water management in relation to maintaining quality, observing regular schedules and ensuring adequate and equitable supply to all residents of the city could be an immediate solution along with needed infrastructural developments.

#### 4.5 Liquid waste disposal and associated health hazards

The wastewater of Sulaymaniyah city is collected via a network of pipes that join into 19 separate concrete underground box channels. These box channels flow outside the city and open to let the wastewater pass through the fields in narrow gullies southwest of the city. The

wastewater of fourteen of these boxes finally flows into Tanjaro River in Sarchinar, Awall and southern parts of the city. The total length of the wastewater network is around 200 km. The openings of some of these channels are located inside the boundaries of the city according to the new master plan. When the concrete boxes open and flow through fields, there is no protection; the wastewater makes its way as an open stream through the narrow gullies which are not fenced or protected by any other means.

Some of these open streams

are now located in villages (such as Kani Goama) and urban residential areas because of the expansion of the city.

According to the Municipality official interviewed, one of the problems of the city is that “wastewater of hospitals, factories, slaughterhouses and the industrial area all mix with the household wastewater and flow to Tanjaro where it is used for irrigation.” Only two newly built hospitals (Shar Hospital and Faruk Medical City) have their own wastewater treatment systems; all other private and public hospitals including Hiwa Cancer Hospital mix their



**Figure 3. Location of wastewater channel outlets south of Sulaymaniyah City**

wastewater with the municipal channels. Over 90% of the city is covered with this sanitary waste disposal system. Some areas on the outskirts of the city and villages that were recently engulfed by the city's expansion are not yet covered by the city's wastewater system, and the residents use self-dug pits to dispose of their wastewater. These areas contain an estimated to 2000 households.

Sulaymaniyah City's wastewater network is considered to be one of the best in the country because of its long history, wide coverage and continuous expansion and maintenance. The topography of the city is



also helpful allowing the easy flow of the wastewater from the higher elevations of the City by gravity down towards the south of the city and the Tanjaro River. However, instances of breakage and spillage are reported especially in the pipes and household connections. An important health risk is the mixing of wastewater with the drinking water supply. However, according to an official, the wastewater channels are deeper than the drinking water pipes network making mixing less likely. "We have two types of mixing of wastewater and drinking water; one occurs when sewerage channels leak and wastewater contaminates water pipes directly causing contamination of the clean water supply. However, these situations are reported to be rare and are usually resolved quickly. The other type of mixing occurs when wastewater leaks and accumulates on the ground causing saturation and contamination of the soil around the water pipes. Since water is usually pumped, the dirt around the pipes might be sucked into the water causing temporary leakage and contamination. Both these mixings are more common in the older parts of the city where some sewerage channels are very old, made with stone and gypsum and thus, are more likely to leak such as has been the cases in the neighborhoods of Saboonkaran and Ibrahimpasha."

All eight residents of Sulaymaniyah City that were interviewed in our assessment reported that they were generally happy about the liquid waste disposal in their houses and neighborhoods; they did not voice any major concerns and expressed satisfaction about the sewerage system and an absence of any health problems related to that system because, in the words of one respondent resident, “the sewerage is covered, all pipes flow to an underground box channel which flows out of the city but I don’t know where to”. Residents living inside the city reported that there were no visible problems unless some breakage or blockage occurred in the neighborhood, which they said is usually repaired soon by the residents in the related houses or by the municipality depending on where the breakage or blockage occurs.

However, in the southern outskirts of the city, the situation is different. During our field visits, we observed lots of human activity around the open wastewater streams next to residential houses. In some places houses and shops are meters away from the polluted sewer streams. People were working in their fields around the streams. Farmers have re-channeled some of the wastewater into smaller irrigation channels that are directed down to their farms and directly to their fields.



**Photo 3. Wastewater of Sulaimaniyah used for irrigation**

During our site visits and interviews, we even observed one of these streams going into a fenced plastic greenhouse. We also observed several farmers watering their vegetable fields with the wastewater. The local authorities acknowledged that this as a health problem, including the health authorities, municipality officials, and the agriculture department. However, none of them have been able to prevent it, “we have tried and continue to try preventing this but the practice is still there and it has increased recently. This is a major problem which we have to monitor continually and destroy all those crops,” said the

Municipality official. Similar opinion was expressed by the agriculture official, “yes we are aware of people using the wastewater for farming; we have encouraged those who are using well water to continue developing their farms and those using wastewater to stop their cultivation but they continue to use the wastewater and we have even been threatened trying to stop them.” Lack of alternative water sources, the free availability of the wastewater, and the perceived beneficial quality of the wastewater were some of the main reasons for this continuing risky and unhygienic practice by the farmers, despite the health risks and the continuous discouragement of this practice by the authorities.

Animals such as dogs, cats and cows were moving around near the sewerage channels, and had direct access to the polluted streams and Tanjaro River. It was obvious that people were also dumping solid waste and garbage into the wastewater streams. We observed household waste, plastic bags, bottles, rugs, cloth, old tires, pieces of broken furniture, animal waste and all sorts of other material thrown into the sewerage channel gullies. No research has been conducted to date on the risks from such activities around the sewerage channels in Sulaymaniyah. Farmers and residents living near those areas could be exposed to dangerous bacterial, protozoal and helminthic infections originating from fecal material, as well as to toxic chemical waste dumped into these channels.

Health risks of exposure to wastewater are related to the presence of inorganic toxic chemicals, organic chemicals and biological hazards. A review of studies on wastewater exposure pathways states that uptake of contaminants into the food chain is the most widespread pathway of concern in relation to wastewater irrigation[13]. Figure 4 from the same study shows the pathways that harmful exposures could take from wastewater to human beings. Even small amounts of heavy metals disposed in the soil would be of concern because of their accumulation and the impact of long-term exposures. Soil type and type of vegetables are the main factors that determine the extent of uptake of the contaminants by plants. A study from India reported high concentrations of heavy metals in vegetables grown with wastewater, and also reported that uptake of heavy metals in the vegetables was highest for iron followed by Cobalt, Copper, Cadmium and Lead, and that the concentrations of all the metals were highest in leafy and tuberous vegetables, and less in the fruit vegetables,

except for iron[14]. Farm lands irrigated with wastewater can retain high concentrations of these heavy metals years after cessation of wastewater exposure as reported by a study from China which reports persistence of heavy metals in soil, plants and hair of farmers from farms irrigated with wastewater three years earlier[15]. In addition to heavy metals, occurrence of active pharmaceutical compounds, detergents, oil gasoline, insecticides, and fertilizers in surface water, groundwater, manure, soil and plants is a global concern [16]. In places like Iraqi Kurdistan where medical waste is disposed in and with municipal waste, and the sewer and solid waste are left untreated and then mix in with rivers, relevant officials should be more concerned about the long-term effect of unsafe disposal these compounds as well.

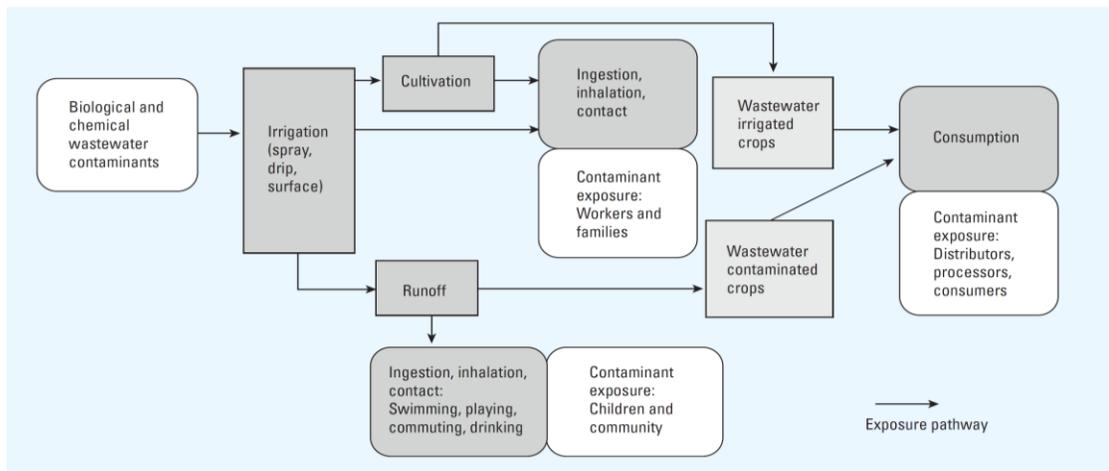


Figure 4. Exposure pathways from wastewater irrigation to consumers, agricultural workers and communities  
 Source: Dickin et al, 2016

While contamination of soil with heavy metals poses a long-term risk, the more immediate risks of wastewater irrigation are related to biological contamination of water, soil and vegetables. Fecal material can contain harmful bacteria, enteroviruses, ova of helminths and other pathogens. Diarrhea was one of the most common diseases reported by people we interviewed living around the contaminated river. Coliform bacteria and some protozoa like *Entamoeba histolytica* are widely known as causes of diarrhea that originate from fecal material. Repeated cholera outbreaks that occurred during the previous years in Sulaymaniyah could also be related to the wastewater and contamination of the fields, but

unfortunately the outbreaks were not properly investigated and the exact causes of these outbreaks remain unknown. The association between exposure to wastewater and diarrhea has been studied elsewhere. A study from Vietnam on risk factors for diarrhea in farmers[17] reports the following significant factors which are all relevant to farmers working around the Tanjaro River: (1) Direct contact with polluted river (odds ratio = 2.4); (2) Handling human excreta in field work (OR = 5.4); (3) Handling animal excreta in field work (OR = 3.3); (4) Lack of protective measures while working (OR = 6.9) (e.g. use of gloves, boots, disinfectants, handwashing); (5) Never or rarely washing hands with soap (OR = 3.3, AF 51%); and (6) Eating raw vegetables the day before (OR = 2.4)[17]. Another study from Ghana reports a positive association between presence of ova of wastewater/soil-transmitted helminths and the stools of farmers exposed. The study reports that farmers and family members exposed to wastewater were three times more likely to be infected with *Ascaris* and hookworm compared to the unexposed control group[18]. A study in Hanoi Vietnam on urban farming using municipal wastewater reports heavy contamination of the samples with total coliforms, *Escherichia coli* and *Salmonella* species[19]. The priority for farmers is irrigation of their crops and if the wastewater is more accessible, some farmers don't worry about or perceive there are health risks, as said in the words of one farmer "we use Tanjaro water because it is good for the growth of our crops, vegetables and orchards and it doesn't require fertilizers; it has no problem to our health." It appears that many farmers use this water, as another 33-year-old male farmer interviewed said, "most of the farmers use sewerage for irrigation especially in the summer when we face water shortages; even though they are aware of the bad influence of using such water for agriculture still they insist on using it." Farmers we interviewed were generally aware of risks of eating raw vegetables irrigated with such wastewater but they said they have no choice. A female farmer justified this by saying "it is not easy to find vegetables grown with clean water; if there is clean water we use it for drinking, not for irrigating vegetables." At times of increased risk of epidemics such as cholera, local restaurants are not allowed to serve locally grown vegetables as a protective measure against the spread of infectious diseases.

While the priority for the farmers is growing their vegetables with easily accessible and cheaper water, this increases the chance of the marketing of potentially contaminated

vegetables. The priority for some consumers is not always a clean and healthy farm products, e.g., as reported in a study from Ghana that indicated a higher priority for the type of produce, the taste, friendship with the dealer, cost, convenience and freshness of the produce[20]. This complicates the picture and makes exposure of consumers to hazardous agricultural products more likely, and poses a challenge to health awareness promotion and disease prevention programs. The only probable viable solution may be to clean or eliminate the contaminated water sources, i.e. open access to wastewater channels. According to the liquid waste official interviewed, there are plans to build the first wastewater treatment plants by a British company. According to this plan, although it is not clear when this work will be initiated, three sewerage treatment stations with the capacity of 250-350 cubic meters will be constructed to treat the wastewater south of the city. This could be the only long-term solution for the wastewater and its associated health risks. It is clear from our observations and from the interviews that misuse of the wastewater could not be effectively controlled or prevented by the authorities, at least at the present time when law enforcement is not effective and financial resources to remedy the problem are inadequate. Meanwhile surveying all the networks, small and large, including the use of GIS mapping, is an essential organizational undertaking which would be useful for any future plans on expansion, maintenance and management of the water and sewerage system.

#### **4.6 Solid waste disposal and associated health hazards**

The solid waste of Sulaymaniyah is disposed of in an open area of a few hectares of land overlooking the Tanjaro River and only 100 meters away from the river banks. The site is around 1 km southeast of the city in close vicinity to residential areas such as the Tanjaro suburbs of Huwana and Chaqlawa villages, and an industrial area with several different kinds of factories and commercial warehouses. The solid waste dump site is not fenced off and it is completely open for cars, trucks, humans and animals to access directly. During the team visit to the city dump site, we observed over 30 people, including children, scavenging in the garbage, and municipality and private vehicles bringing in waste. Scavenging animals (dogs, cats and rats) and birds were also observed moving around in the garbage throughout the dumpsite.

The municipality official in charge of solid waste disposal told us that daily production of solid waste in the city is approximately 1,200 tons which increases to 1,250-1,300 tons during feasts and celebrations. The waste is collected and disposed by the Municipality (25%) and four private companies (75%) contracted by the Municipality. The official of one of the private companies said that “the composition of the garbage is a mixture of food, glass, paper and other materials of which we monthly collect and dispose of about 5,044 tons.” Altogether, about 1500 workers are involved in collecting and disposing the garbage for Sulaymaniyah City. An estimated 60% of the garbage is organic material, mainly food and about 4-5% is plastic and disposable containers. Garbage from the majority of hospitals (75%) is also disposed of at the dump, along with the municipality waste. There is only one incinerator in the city which burns some medical waste and the ashes are then later disposed in the same city garbage site. Garbage of all private clinics, and there are hundreds of them in the city, is also mixed in with the household waste at the dump site. This was also confirmed by a disposal company official who stated that the garbage they collect is a mixture of all kinds of garbage, including solid waste of the hospitals, except for the waste of Hiwa Cancer Hospital and the Teaching Hospital which are disposed at the City’s Tanjaro garbage dump site directly by the hospitals themselves. The waste site monitor who we interviewed had seen this in the most dramatic way, citing “one incident which continues to haunt me is that one day I saw a dog holding a human part in his mouth which it had found inside the waste from the Emergency (Burns) Hospital.”



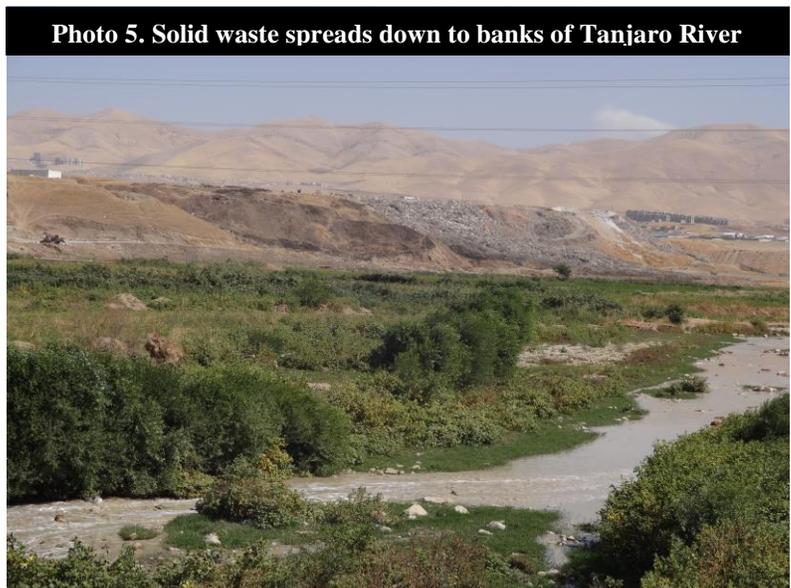
The official agrees that the solid waste disposal system is primitive “from 2005 onwards till 2012 we used to dig 10m\*10m pits to bury and cover the garbage in the same place. However, since the recent financial crisis this procedure is not done any more and as you

have seen the garbage is disposed in that primitive way.” He is also aware of the health and environmental problems associated with this kind of disposal:

*“Sure this is primitive and we know the health risks which we have discussed repeatedly but there is no other choice. It has polluted our water, soil and air, this waste enter the Tanjaro River and then flows to Darbandikhan lake which provides water to the population in that area. In addition the water is used for agriculture and by animals, exposing the health of the population to many risks.”*

The garbage is taken to the garbage site by special garbage dump trucks and regular trucks and disposed on the open flat ground. According to one waste site monitor interviewed, daily around 1,400 tons of garbage are disposed in this site. While trucks dispose fresh garbage, a loader pushes earlier piles of garbage down the valley towards the Tanjaro River and throws buckets of earth over it. Since the valley is steep, this procedure only mixes some soil with the garbage and does not even partially cover the waste. You could see piles of garbage dispersing from the hillside all the way down towards the agricultural fields on the northern banks of the river. All kinds of different material are seen in the site, including household garbage, hospital medical waste, garbage from factories and discarded construction materials. The smell is strong, unpleasant and unbearable. The Environmental Health Assessment team also observed some smoldering piles of garbage during their visit to the site.

The northern bank of the river stretching directly below the garbage site is cultivated with vegetables. The piles of solid waste lie right next to the fields separated by a 1 meter high soil embankment which is half-filled with a filthy yellow-brown oily acid-smelling liquid leaching out from the piles of waste covering the steep hillside and valley. The



The team observed a black layer of asphalt covering parts of the soil. It is quite possible that

during rainy periods the embankment fills and the liquid spreads into the agricultural fields and flows into the river nearby. It should also be noted that during the Environmental Health Assessment team’s visit to the dump site, cows were observed grazing in the fields just below the toxic leaching area and were walking in the river streams just below the dump site.

It appears there are no written guidelines and regulations about collection and disposal of waste, or about safety procedures and guidelines for staff and local populations. As stated by one of the company officials “in relation to written guidelines, no one has given us any guidelines, only the Municipality has only designated an area for disposing the waste of the city and told use to cover it with soil.”

Ideally, sanitary landfill is done by following specific procedures and using appropriate technologies to strictly enclose the garbage and minimize spread of the percolating liquids to the soil, thereby minimizing the risk to human health. A less effective way to handle garbage is through controlled landfilling, in which the garbage is covered with earth without any consideration for the infiltration and release of leachate and biogas. However, what is currently being done in the Sulaymaniyah City garbage dump site is a very poor quality and uncontrolled solid waste landfill where the garbage is pushed down the hillside and very inadequate attempts are made to throw some earth on the newly dumped garbage. Huge piles of garbage spread down the valley without being covered.

The Sulaymaniyah City garbage disposal site is essentially an open dump site with only partial and inconsistent attempts to cover some of the newly dumped garbage. Probably the worst part of the garbage disposal site is its close proximity and



**Photo 6. Leachate liquid swamping near the river**

direct access to the Tanjaro River. Large amounts of leachate could be clearly seen flowing

from under the garbage piles down to the banks of the river. While parts of this leachate also infiltrates the soil down its path, and on the flat river banks it infiltrates the soil even more easily. The one meter or so high soil embankment which is made to separate the leachate and garbage at the base of the dump hill from the streams and Tanjaro river close by was half full of liquid leachate during our visit to the site in the latter part of the dry season. There is no doubt that large parts of the leachate enter the river either through infiltration to the soil or during the rainy seasons when the contaminated soil and the accumulated liquid leachate is washed away to the Tanjaro river, that then finally takes some of this pollution all the way to Darbandikhan Lake.

The people who were searching in the garbage during one of the visits, were of both sexes and all ages from as young as 6-7 years old. Some had piles of plastic bottles or cans collected and ready to be taken away. A few of these people were wearing masks, but the majority did not wear gloves



and masks. When we arrived at the site and parked our car about 100 meters away from them, instantly a few young men came and warned us about taking any close-up photographs or videos. “No photos please, in the past we have seen social problems arising for some of those people because they were photographed while working,” one of the gentlemen said. According to the site monitor, those scavengers were poor people from surrounding suburban areas, some local residents and some others where internally displaced persons (IDPs) who came from conflict areas, searching to find anything that they could sell. One of the dump worker employees said that “every day, around 70-75 persons come and scavenge in the waste, they usually search for plastic, glass and iron and any material which can be used again as raw materials.”

Working with the waste has occupational risks to people handling it, whether they are waste collectors or scavengers especially if they are not using protective equipment. These problems include injuries with high risk of subsequent infection; respiratory disorders skin problems and allergies. The waste monitor had witnessed one case of an accidental death during the past 7 years (a worker run over by a garbage truck), but injuries were said to be more common and “verbal quarrels and disputes happen regularly with truck drivers and it is very annoying because they do not listen to the people who work here.” In relation to the waste collectors, the manager of one of the companies reported that during recent years they had not seen any disease outbreak or major health problem in their workers that could be related to their work. However, the manager said that “sometimes they get injured by pieces of glass in the hand or feet, and those working on the streets sometimes get injured when hit by passing cars.” The company rules require workers to use protective gears including visibility jackets, gloves, and boots and in cases of violation, they are subject to a penalty of 15,000-25,000 ID. Our observation also indicates that gloves are usually used by hired workers, but masks are rarely used by the paid workers.

An Indian study on waste collectors reports a 12-18% prevalence of respiratory disorders, a 5-44% prevalence of injuries and a 35-49% prevalence of allergies in waste collectors [21]. This study also reports that 22% of these workers and local residents did not use any protective gear.

Data from the literature has also suggests an increased risk of cancers of liver, kidney, pancreas, and non-Hodgkin's lymphomas in people living near landfill sites. A Canadian study assessing cancer risks in people living near a municipal solid waste landfill site in Montreal found statistically significant increase in risk of cancers of pancreas (OR 1.4), liver (OR 1.8), prostate (OR 1.5), and non-Hodgkin’s lymphoma (OR 1.5) [22]. Bearing in mind the sanitary landfill site in the Montreal study area, such health risks could be expected to be much higher in the more uncontrolled and considerably less sanitary garbage sites of Sulaymaniyah.

A Nigerian study reports significantly higher concentrations of heavy metals in the vicinity of a municipal solid waste dumpsites compared to control sites including Pb (9.90), Zn (137), Ni (12.56), Cr (3.60), Cd (9.05) and Mn (94.00) in the rainy season; and Pb (11.80), Zn (146), Ni (11.82), Cr (4.05), Cd (12.20) and Mn (91.20) in the dry season[23]. The study also reports that cadmium was responsible for the highest ecological risk index and that children living near the site were found to be more at risk of heavy metal contamination.

A review of the literature also found reports of increased risk of hepatitis B and C in workers collecting urban solid waste when compared with people who have no exposure to solid waste[24]. A study of Egyptian solid waste scavengers reports that 48% of these people were found to have one or more protozoan or helminthes infections, including *Ascaris lumbricoides* (26%), *Schistosomiasis* (19%), and *Entamoeba histolytica* (1.6%). The study also reported higher rates of physical hazards and general illnesses among the waste scavengers [25].

Sulaymaniyah City residents that we interviewed generally reported that they were satisfied about garbage collection in the city. They reported collecting garbage in plastic bags which are then picked up regularly by the vehicles, every day in some neighborhoods and every other day in others. But some neighborhoods were reported to have problems of garbage littering. For example, a 27-year old women resident that was interviewed said “we don’t have a problem but there is an open area near our house where some people throw their garbage and it accumulates until sometimes a municipality vehicle comes to dispose of it.” The market garbage is collected and disposed of regularly at night that helps to keep the city clean. People were also not very concerned about any personal health risks from dealing with household garbage at their homes.

Garbage production both at the household level and at the market level is high. This could be related to attitudes and traditions at home and use of excessive packaging and the increasing trend in using disposable material such bags, plastic and various containers at home and in the market. Reduction of non-organic garbage production could be an important strategy to work on. As long as garbage trucks operate regularly, residents will be happy to use them, but disposable material is widely seen littered everywhere on streets, roadsides, picnic sites

and basically everywhere people go. In addition there are fears that the current system of garbage collection may further deteriorate and be disrupted by the continuing and worsening financial crisis.

The Municipality has thought of recycling the waste for years but in terms of actual plans, there was an agreement in 2015 with Lafarge Company to recycle solid waste of the city. However, this never materialized due to a lack of funds and a failure to allocate other resources such as land and electricity for the project as reported by the officials. For a relatively prosperous and rapidly growing region like Kurdistan, solid waste management should have been a priority during the past 10 years when the region was well-funded, not at this time of austerity when even basic services cannot be adequately managed. There seems to be little hope, if any, for the recycling plan to be revisited any time soon. The most appropriate plan at this time, until funds are guaranteed for recycling, could be establishing a controlled landfill in an area farther from the river banks where the flow of the leachate to the river could be minimized.

#### **4.7 Industrial pollution and associated health hazards**

According the official reports, in 2014 there were 89 big industrial enterprises, 182 medium-sized enterprises, and around 10,400 small enterprises in Kurdistan Region[2]. According to the Directorate of Industry in Sulaymaniyah, around 1,650 small and medium-sized factories are registered in the directorate,



**Photo 8. Polluted waters of Tanjaro River**

excluding the big factors which are licensed by the Ministry of Industry. The main area of industrial activity is located southeast of the city near the Tanjaro River where around 900

businesses are located, including factories of plastic, Iron, oil, concrete block, asphalt, and other construction material. The industry official interviewed acknowledged the dangers of all these factories around the river stating that “we are all aware that the establishment of all those factories in that location poses hazards to Sulaymaniyah population, but this was planned in the past; in the new master plan a different location is allocated near Arbat for industrial activities. However, it has not been implemented due to lack of budget.” Although the new location will be further away from Sulaymaniyah city, it will still be close to the Tanjaro River and overlooking the river still poses the same dangers to the environment if no proper measures are taken to protect the river and the general environment from industrial waste contaminants. Currently, the liquid waste from many of these factories flows to the river and their solid waste is disposed of at the city’s solid waste disposal area that is near the riverside.

Factories, workshops and businesses of up to 75,000,000 ID also have to be registered at the Chamber of Commerce (CoC) in Sulaymaniyah. According to the CoC in 2016, there were 1,451 big projects, 1,898 small projects and 867 entrepreneur workshops in the governorate. However, many of these projects are not functional especially the small ones of which only about 700 are currently operating. The big factories are licensed by the Ministry of Industry and therefore, they are not followed-up and are not bound by CoC regulations. Neither the Directorate of Industry nor the Chamber of Commerce seem to have any specific policies, guidelines and regulations about environmental protection and safety operations in relation to industrial activities. The only instructions are occasional directives from the Ministry or the Directorate of Industry about specific issues or activities of the factories. For example, the factories are instructed not to burn plastic waste, but what they probably do is dispose the plastic at the municipality waste site. It is clear from what the officials said in the interviews and meetings that even the few instructions that are presented to factories on environmental safety issues are not followed properly.

The industrial directorate has a monitoring team that visits the factories mainly to ensure that they maintain a valid license. However, even these teams according to the official, have not been able to visit the factory sites during the past 6 months because of the financial crisis. There is another committee including a



health professional who is supposed to visit the factories once a year to check on issues related to workplace safety. However, the absence of clear policies, guidelines and checklists on environmental and workplace safety makes any such monitoring activities hardly effective in introducing change towards better and safer practices and higher standards in protecting the environment and reducing health risks to workers and the local populations living around the factories. The absence of polices, regulations and guidelines; poor monitoring; the highly polarized and politicized environment and the uncontrolled pursuit of profit by influential people, make it extremely difficult for the relevant governmental departments to promote and achieve quality and safety standards in industrial production. Although this was not clearly stated by the officials whom we interviewed, it was not hard to detect these sentiments in their statements.

The major industries in the governorate are cement and oil, but these were not focus of the current assessment. There are an unknown number of oil extraction sites and refineries in the governorate that could be a serious reason for concern on environmental pollution. However, because of the nature the oil industry and the fact that it is managed by the major political parties, it is not easy to accurately and reliably assess the environmental situation for this industry. The cement industry is concentrated about 20 kilometers west of Sulaymaniyah city where a number of modern cement factories have been established in the Bazyan area during the past few years, and the impact of these cement factories on air pollution may need to be

considered in future environmental research studies, especially the occupational health risks for the workers and for residential populations living in the vicinity of these factories.

According to an official from the governorate's fuel committee, the daily needs of Sulaymaniyah governorate for gasoline is estimated to be approximately 2 million liters, half of which is locally produced and half imported from neighboring countries. Gasoline is leaded and sold in 3 octane levels according to measured octane ratings, ranging from 88 to 95. There are approximately 200 modern petrol stations that follow safety standards and about 50 illegal ones. The oil industry is not transparent and there is no official information about number of oil refineries, which includes an unknown number of illegal refineries. Kerosene is also widely used at the household level, especially in winter since it is the main heating fuel for homes. Kerosene is mainly brought from the central government of which 30 million liters were recently bought and distributed, and it is planned to sell and distribute a similar amount again soon. Fuel is stored in special tanks and according to the official interviewed, there have been no reports of major leaking incidents from storage tanks. However, there are repeated incidents of road traffic accidents involving fuel transportation tankers burning or spilling the fuel out on the road and ground nearby. Also, "there are environmental health concerns in the Tanjaro River area, especially about illegal refineries located on agricultural lands." The expanding and non-transparent oil industry and the fuel trade should be areas of grave concern for environmental health authorities, and as one official said "it needs to be organized and regulated by law, but unfortunately it has not been transparent and regulated and they don't want it to be."

A review of studies on health hazards of living near industrial installations [26] reports that living in the vicinity of industrial parks is associated with higher rates of perinatal health problems, neurological defects and other congenital anomalies. The study also reports higher risks of childhood leukemia and non-Hodgkin's lymphoma in people living near busy highways that could be related to exposure to higher benzene emissions. Urban air pollution from smoke and dust is well known for their adverse impact on respiratory diseases and exacerbation of asthmatic episodes. Research has shown that in addition to first hand smoking, household pollution and long-term exposure to asbestos, chromium, arsenic and

other heavy metals could pose significant risks for the development of respiratory diseases and cancers [27]. Lead is one of the heavy metals of special concern in Iraqi Kurdistan because of the variety of its emission sources including poor quality of petrol, wide scale use of leaded paints in industry and unsafe disposal of car batteries and other batteries and lead products into the solid waste sites, and finally into the soil and water sources. This especially could be an occupational hazard for people working with paint, batteries, tiles, welding and other industrial sources that use lead as well as for the people living in highly polluted urban centers and the congested downtown areas of major cities [28]. A study from Ethiopia reported unsafe concentrations of heavy metals (Pb, Cr, Cu, Cd, Co and iron) in the wastewater of paper mills and unsafe concentrations of Pb in some green vegetables grown with this wastewater [29]. People could be exposed to pollutants through a variety of pathways depending on the source and the type of release. In urban settings, the most common pathway is likely to be inhalation from air polluted with particulate matter and smoke from a variety of sources including dust, household pollution, factories, and motor vehicles and burning of waste. Potentially toxic elements could also enter the water and food chain and be indirectly transmitted to humans. The presence of hundreds of factories in Tanjaro River area, the disposal of the solid waste near the river banks, the contamination of the water and surrounding fields with wastewater, and the fact that the Tanjaro industrial area is downstream and low, puts the population living in these areas at higher health risk from pollution from all the above mentioned sources. [30].

People living in the area are deeply concerned about these risks. For example, as a 32 year-old male resident living in the area put it:

*“These factories, the solid waste and wastewater will affect us in the future and we get chronic diseases especially our children. One day we may regret living here but we don’t know now and we have no choice, where else can we live? The families on the other side near the oil factory are suffering from dizziness, fatigue and always feel weak and dizzy because of the oil factory.”*

Similar views were expressed by a 47 year-old woman from the same area:

*“The main pollutions here are cement, oil, garbage and noise. We have experienced diseases such as goiter, kidney problems, and shortness of breath, dizziness, headache, diarrhea and colic. Everything is dirty here, full of diseases; if we had money and life*

*we wouldn't stay here. Poor people have no choice but get used to it. When I was a child we used to drink Tanjaro water, but now come one morning and have a look at the water!"*

Many of the residents of the industrial area are poor workers living in simple houses and unsanitary conditions. A young woman, adding skin allergy to the list of health problems in the area explained "this is a residential area, we have built our houses without license from the municipality, therefore they do not let us drain sewerage to the channels; there are lots of environmental hazards here, life is impossible but we cannot afford to leave the area." Environmental health hazards are not equally distributed in urban and suburban areas. Some urban areas south of Sulaymaniyah city and in suburban areas around Tanjaro are clearly at a disadvantage in relation to health equity. Studies have shown that disadvantaged areas, such as these parts of Sulaymaniyah, involve more health hazards because of unhealthy housing, presence of industries, toxic products, air pollution, noise, injuries and ergonomic hazards [31]. Poverty, pollution from the sewerage, the garbage and the factories are recurring themes in the people's views collected in this environmental health assessment, and similar types of health problems are often cited, including fatigue, headache, dizziness, diarrhea, bronchitis, shortness of breath, kidney problems and goiter. Perceptions of people about their vulnerability to environmental risks seem to be related to their living conditions, health awareness and level of deprivation. A 43 year-old factory worker living in the area put it in the following way:

*"Most people of this area live here because they are poor, destitute, they have no means, no income, they do not have good water for drinking, their air is polluted, their area is polluted and the Municipality does not clean it for them as it always gets dirty again because the Municipality does not give them garbage bags and they cannot afford to buy them. Garbage trucks come here rarely or never come at all, and that is why it is always dirty."*

Living in the vicinity of these pollution sources and being the most aware and affected people by the pollutants, any socially responsive and equity-focused program for the mitigation of the environmental health hazards should involve these populations throughout the assessment, planning, implementation, and program evaluation stages.

Some of the bigger and more modern factories try to abide by safety regulations at least within the boundaries of their factory. One factory manager told us that their products are “manufactured under ISO standards, they have a health and safety department working under the guidance of ministries of health and industry and the workers generally use PPE such as protective suits, helmets, gloves and masks, but sometimes they don’t because of the heat and for some it is a habit not to use PPEs.” It seems even in these modern factories enforcement of worker safety regulations is not properly done. In smaller factories and workshops, safety is not a priority and workers don’t find those PPEs available or convenient to use during work. It also appears that the impact of the factories on the environment is not much of a concern for the factories, especially as there are no clear guidelines and regulations about environmental protections provided by the relevant authorities, and monitoring and enforcement of any existing guidelines does not appear to be done effectively or is not done at all. Factories either burn or bury their waste or dispose of it at the main garbage disposal site. A factory foreman acknowledged, “our work might have some risks to the environment, especially as we use nitric acid and heating to clean the oil, but we have to remember that before this factory started operation, all of the used oil of cars was disposed of into the sewer or spilled out on the ground, which could have had even more risks to the environment and human health; so our work is considerably safer than before.”

Smooth operation and production is the main priority for factory managers, as one factory manager said, (and they will appreciate any support along this line), “there are currently no new plans to reduce environmental pollution and occupational health risks and improve health and safety at our factory, but we are ready to abide by any regulations coming forth; we have to remember we are doing important work in reviving the country’s infrastructure, creating job opportunities and marketing local industrial products.” The factories indeed have a role in producing economic development of the region and creating jobs, but without proper support and monitoring from the government and professional institutions in terms of providing regulations, standards and training related to occupational safety and environmental friendly operation, they cannot be expected to be without problems.

#### 4.8 Agricultural practices and associated health hazards

One of the important pathways of transmission of environmental hazards to humans is through the food chain. Microbiological hazards and potentially toxic elements and other hazardous compounds can get into the food products and gain access to human body through ingestion of food and water. These hazards can also accumulate on the surface of vegetables and be transmitted to humans directly. Urban and peri-urban farming around Sulaymaniyah city using the wastewater and the polluted Tanjaro River continues to be a serious issue of concern by most officials and several residents we talked to. The southern parts of the city and the areas around the Tanjaro River are cultivated with crops and vegetables with little or no control from relevant agriculture, health and law enforcement authorities.

According to an official from the directorate of agriculture that was interviewed by the team, there are around 1,000 donum of irrigated fields in the city. In relation to summer crops grown in and around the city boundaries, the area of fields cultivated with summer crops is over 2,000 donum in Bakrajo, over 9,000 donum in

**Photo 10. Wastewater stream diverted for irrigation**



Tanjaro and over 1,000 in Bazyan. The area of fields cultivated with winter crops is 81,000 donum in Tanjaro, 46,000 donum in Bakrajo and 33,000 donum in Bazyan. The main winter crop produced in these areas is wheat and the main summer crops which are largely sold in the city are cucumbers, tomatoes and various kinds of other vegetables. The vegetables are consumed locally and since they include leafy vegetables eaten raw, they are of special concern in relation to transmission of infectious diseases including diarrhea, protozoal and helminthic diseases, cholera and other water and food-borne diseases. In addition crops grown with water polluted with solid waste and industrial waste, could be source of

potentially toxic elements and compounds that could have long-term effects on the health of consumers.

In theory, the agricultural department should supervise the cultivation and distribution of these crops in terms of quality, quantity and production, taking into consideration issues related to population health. However, in practice, especially during the past few years, the agricultural department's support has been very limited due to the financial crisis. Very little has been done in relation to securing and controlling their agricultural water sources and the provision of pesticides and chemical fertilizers. The agricultural department official interviewed was aware of the risky practices in agriculture and concerned about the farmers use of wastewater for irrigation, but apparently the department can do nothing to stop it: "Yes, we are aware of people using wastewater for farming around the city and we always encourage farmers who are using well water to continue developing their farms and those using wastewater to stop their cultivation but they do not listen to us and we have no power over them; they continue to use wastewater for agriculture."

In the past the agricultural department used to distribute fertilizers such as urea and DAP- a kind of mixed fertilizer. The farmers now buy and use whatever fertilizers and pesticides they find in the market and since the market is not controlled and traders can import anything, concerns about presence of unsafe and non-standard products are legitimate. The department does not support and now even prohibits the use of growth hormones in the fertilizer and feed. However, officials were aware that some farmers use these growth hormones especially in the plastic houses, "they buy it in the market despite our instructions; some hormones stay in the product for 7 days after use, but some farmers pick the products after 24 hours and send them to the market which might cause health problems." There is a section for agricultural guidance to provide instructions to farmers in relation to use of fertilizers and pesticides and other issues, but their activities have also been greatly reduced in the past few years due to the financial crisis.

Addressing the problem of unhealthy practices in farming, and the mitigation of risks to human health, cannot be accomplished by the agricultural authorities alone, according to the official. Addressing these issues also requires to support and participation of the municipality

government, health sector, and department of the interior, as well as the agricultural authorities and the local farmers themselves. The agricultural fields are not protected, and many are irrigated with unsafe water and there is no control of what and how fertilizers and pesticides are used. Supervision and control of these aspects require collaboration of the above authorities to establish regulations, provide guidance and awareness-raising activities, enforce regulations and impose penalties on farmers not abiding by the regulations. Even the agricultural department itself might need to establish and enforce stronger polices and regulations, especially in relation to quality control of local products, as there are currently no quality control tests for crops, and the products directly go to the market. Imported agricultural products are only subject to visual inspection. There is a center for agricultural research at the department for agriculture but in practice it does not have any significant activities.

The Environmental health Team's field observation visits in October 2016 to the agricultural fields south of the city and around Tanjaro River found a good amount of agricultural activity at the outskirts of the residential areas, all the way down to the river banks. The cultivated fields were mainly vegetables



such as leafy green vegetables, radishes, turnips, chard, corn, tomatoes, okra, cucumbers and similar products. There were also some poultry yards and animals farms (e.g., cows). The activity was more intense and the farms were greener around wastewater outlets. The team observed irrigation channels diverted off from the main wastewater stream travelling directly through the fields and even entering a plastic house farm. Some farms were watered using ground water from private shallow wells or deeper wells dug in the fields, especially those farther from the course of the wastewater stream.

The fields were usually small, simple and not organized and lacked any sanitary facilities such as clean water and toilets. Apart from the plastic houses observed, the farms are not physically isolated or fenced off but completely open to humans and animals. Except for plowing, it appears that all other work is done manually. Farmers were observed watering crops without wearing any gloves and masks, but some were wearing boots.

The villages in the area have different sources for drinking water. Some villages have deep wells, others have shallow wells and some get water through water tankers (trucks), especially in summer. When the village has a water project, the water from the deep well is connected to a storage tank and taps. Houses usually have private latrines connected to pits. Villagers who are served by a water project are usually happy about their drinking water especially those farther from the river. Those closer to the river have some concerns about the quality of the water as expressed by a 33 year-old male villager near the river.

*“The only source of water we have is a hand-drilled well 21 meters deep. Even though it is fairly close to the Tanjaro River, we must use it as we don’t have other options. I am not quite sure about the quality of water, but I don’t think it is clean because we always feel unwell. Otherwise, when you look at the water it looks nice and we rarely notice changes in color and odor.”*

Being in danger of contracting diseases from sources of pollution, including the river water, factories, wastewater and solid waste is a recurring theme for the farmers living in villages near the Tanjaro River. A 35 year-old farmer said “because our living site is close to all these sources of pollution, our life is in danger and the longer we stay in this area the more is the danger on our lives and we may get diseases such as asthma, anxiety, shortness of breath, cholera, and vomiting- if we have not yet got these diseases we will catch them in the future.” A 56 year-old female farmer explained her concerns in more detail:

*“People who live nearby know that living here is very hard and there are different types of diseases and health problems. The dirty water of the Tanjaro River and the filthy air of the factories make us sick with shortness of breath, asthma and kidney disease. This is not a place to live, but we have no choice. Every year our children get sick between September and October, especially this year with diseases like*

*diarrhea and vomiting. And the adults, we sometimes feel short of breath and get headaches.”*

A woman from another village described another picture of health problems facing the population:

*“There are many people suffering from diseases because of environmental pollution. The population of the village is 150 of whom 15 are suffering from asthma and about 40 have anemia. We also get vomiting and shortness of breath. Especially during summer it is very hard, each day is a death in itself.”*

Farmers living near the river and the industrial area attribute most of their health problems to the environmental pollution they see around them so visibly and they are very conscious about it. However, their own actions seem to be of less concern. They don't see much harm to themselves in using the polluted water for irrigation, using fertilizers and pesticides, and failing to use personal protective equipment in their work. It was clear from the interviews that almost all farmers whose lands are near the river use the polluted water for irrigation, and use chemical fertilizers and pesticides, without taking much precautions to protect themselves from the potential adverse effects of these unsafe practices. A 29 year-old male farmer said:

*Yes most of the farmers, including myself, use wastewater for irrigation because it provides a very good source of water and it is full of nutrients for the plants. We are aware about the badness of using this sort of water for irrigation but we don't have other options. In some situations in the past when the government banned using wastewater for agriculture people started using it at night.”*

On using personal protective equipment, a 33 year-old male farmer said “personally I do not use such things during agricultural activities; some farmers use masks rarely and some farmers put on gloves sometimes.” A 39 year-old women said “My skin is quite sensitive so I usually use gloves, but my sons and husband don't use anything to protect themselves, they don't care”. Even though some farmers believe that these practices might expose them to health risks, they find gloves, boots, and protective suits and masks inconvenient to use, interfering with their work, not essential or an extra luxury as a thing to use in their work.

Another important health-related practice in these areas near the city is using wastewater and polluted water for growing seasonal summer vegetables as discussed in an earlier section. Since seasonal crops and leafy vegetables are used on a daily basis by the farmers, and these

crops are also easier to sell in the market, their cultivation is widely practiced. The danger of these vegetables such as cucumbers, tomatoes, lettuce, radishes, parsley, green onions, etc. is that their raw consumption could lead to infections with parasites and microbes. Some farmers, such as the 56 years-old woman quoted below, are aware that eating these vegetables could be associated with health risks, “eating raw vegetables is bad for our health and our children’s health, like diarrhea and vomiting, but we have no choice we can only live here.” Others, including this 23 year-old man did not think there were any health risks: “I think using raw vegetables does not pose any problems to human health.” Vegetables are an essential part of diet in the region and cannot be abandoned. In addition, the risks to the farmers do not happen only by eating them raw but also during watering, picking and handling. Because of the absence of other water sources, at present, it may seem useless to try to discourage farmers from using the polluted water of Tanjaro River for farming. Until measures are taken to protect the river from pollution, or to provide alternate safe water sources for farmers, only proper guidance can now be given to the farmers on safer farming practices, such as wearing personal protective equipment and proper washing of vegetables before eating. Using Sulaymaniyah wastewater for farming must be ultimately be strictly prohibited, but this is currently difficult to do as expressed by key informants the EH team interviewed, and it will require strong leadership, and additional resources, as well as enforcement actions from health and law enforcement authorities.

Exposure to and/or transmission of the potentially toxic elements and compounds from the polluted soil and water to the agricultural products is a real probability in the fields irrigated by the water from the Tanjaro River, throughout its course from Sulaymaniyah City to Darbandikhan Lake. Impact of this contamination on human health is a long-term one and is not immediately visible. This may be one reason for the absence of serious efforts and political will to recognize the problem and to adequately respond to it. As discussed in an earlier section, contamination of the food chain with these environmental pollutants could expose consumers in the long-term to serious negative health effects, including cancers. This issue should be taken seriously by the professionals, including relevant local authorities and political leaders, since its solution is not easy and requires sustained action and financial and human resources at all levels.

#### **4.9 Darbandikhan Lake and associated health hazards**

According to Darbandikhan Dam officials, the dam was built during 1956-1961 time period, and it is composed of two main parts, one of reinforced concrete and the other an earthen soil-based component. The dam is 535 meters in length and its height is 128 meters. The altitude of the lake water is 485 meters above the sea level and the top of the dam is at 495 meters. The original capacity of the dam was 3 billion cubic meters, including 2.5 billion live capacity and 0.5 billion dead capacity. However, currently the capacity has been reduced to approximately 2.6 billion cubic meters because of sedimentation reducing the dead capacity to less than 0.1 billion.

The lake is the source of drinking water to for an estimated 500,000 people in Darbandikhan and a number of smaller towns nearby. The water is pumped to a pool at the river side and, from there, to three storage tanks before being distributed to the households via the city network. Checking the quality of the pumped water is done once a month using a limited number of tests such as pH, alkalinity, electric conductivity, nitrate, zinc, iron and turbidity. Although this is surface water and exposed to various sources of contamination from the feeding rivers and tributaries, there is no water treatment plant for filtration. The Dam official interviewed expressed concern about the water quality and did not believe it was suitable for drinking as such because “wastewater of Sulaymaniyah and other towns flow to the lake via the Tanjaro River; waste of a large number of factories is brought here via the same river; farmers wash their domestic animals in the lake using probably poisonous materials; and in addition, the lake is also polluted by municipal and industrial waste from Iranian towns via Sirwan River.”

Residents of Darbandikhan are equally concerned about the water in their houses. “They all get this water through the network, but that does not mean they all use it for drinking and even for washing purposes,” said the official, himself being a resident of the city. The local residents we interviewed all said they were not using the water for drinking; they usually use it for washing and cooking. A 37 year-old female resident said “we use well water, we never use water from the Darbandikhan Dam project for drinking because it is very dirty, it tastes and smells bad; but we have no choice but to use it for bathing and washing.” The residents

generally use and share water from shallow wells. “We have a well, but we use a water filter for that because the water is a bit greasy and turbid, but previously we were using the government water and used to have some diseases such as sore throat, headaches and kidney problems,” said a male resident of 50 years of age. This resident was so concerned about the unhealthy water they were getting that he mentioned all the cities and towns polluting the lake, “ the government is responsible for the pollution of the lake because they do nothing while they know that waste of Sulaymaniyah, Nasr, Barkia, Halabja, New Halabja, Zarayan, Saidsadeq, Paveh-Iran and Jwanro-Iran all flow to the Lake.”

Residents are clearly aware that being near the lake and consuming its water endangers their lives, but like most people, they do not know what the risks are exactly, and to what extent. As they are so worried, they easily attribute many of their health problems to the pollution. A 33 year-old resident said:

*“Life is very dangerous here. There are so many common diseases such as diarrhea, vomiting, skin diseases, kidney problems, liver virus and liver cancer. The majority of the patients of Hiwa Cancer Hospital are from Darbandikhan,”*

The residents were also concerned about vegetables grown on the banks of the river using the lake water as well as the city’s wastewater. As a confirmation of those concerns, when we asked local residents about how protected they felt they are from environmental hazards, on a scale of 0 to 10, where “0” (zero) is not feeling protected at all to “10” feeling totally protected, the average score number of their replies was “2”. The Dam official reiterated the health concerns of the population, especially about diarrhea, viral hepatitis, kidney problems and cancer, noting that "a good proportion of Hiwa Cancer Hospital patients are from Darbandikhan." There might be some evidence behind such widely held opinions and health concerns, especially about cancer in the city. However, more scientific epidemiologic research needs to be conducted to verify or refute these concerns. As we cited earlier in this report, research in other countries has suggested an increased risk of cancers of liver, kidney, pancreas, and non-Hodgkin's lymphomas in people living near landfill sites [22]. A lifetime

of exposure to polluted water even with minimal elevations of potentially toxic elements could be risky to the population.

Interestingly, the lake management mandate does not include prevention of pollution of the lake water and the removal of pollutants, and therefore they do not have any professional or infrastructural capacities or guidelines to assess, monitor, and respond to lake water pollution.

Darbandikhan Lake provides livelihood for many fishermen who work on the lake throughout the year, except in seasons when fishing is prohibited. They know the lake better than anyone else and appreciate it, as it is the source of their income, as a 44 year-old fisherman stated: “I know all corners of this lake and I go fishing everywhere from the Tanjaro River to Darbandikhan Lake.” Some of the fishermen evidently consider the water to be clean and have no worries using it for all purposes. One fisherman stated: “No, the water is not dirty, I drink from this water and I have never got sick; it is true I have often seen animal corpses in the water, but I do not think that causes pollution of the water because they become food for the small fish which we call Janka.”

Even when he was reminded about wastewater and garbage being dumped into the lake the fisherman said “this lake is so immense it never gets dirty.” However he confirms that the water is cleaner in winter and spring because the water becomes “even more immense.” He uses the water for all purposes, including drinking, cooking and making teas, “in fact the best tea I have ever drunk is the tea I make from this water.”

However, this is not what all fishermen believe. A 39 year-old fisherman interviewed expressed a completely opposite opinion:

*“The water is very dirty; I can say it is like nitric acid, full of virus and microbes. I have seen many car batteries in the water which is dangerous. I have also seen many animal corpses, but I don’t think these pollute the water because very soon they will be eaten by the fish,” the man said.*

He does not drink from the lake, “no, I never use it for anything- if I die of thirst, I will not drink a drop of this lake water and will not use it for anything else; I either bring water from

home, or I go and fetch water from fountains on the mountain for drinking and tea.” Contrary to his colleague, he believes that even in winter the lake is dirty, “the amount of water changes during various seasons but it is polluted in all seasons; the thing is that in winter when it floods all waste of Sulaymaniyah and the new Halabja and the slaughterhouses drains to the lake.”

In relation to health problems from working in the lake water, both of the fishermen interviewed did express some concerns. The 44 year-old man said he had problems of hair loss on his legs and feet. His colleague had the same problem of hair loss in addition to fissures in the feet and skin inflammation. Apart from these skin problems, they had not experienced other diseases which they directly related to their working in the lake water.

When asked about unusual events they have witnessed in relation to fish life, they both stated that every summer in the area of Jardasna where Sirwan and Tanjaro rivers meet, lots of fish called Raqqa die. According to the fishermen this happens because of a decrease in the amount of oxygen in the water. This phenomenon occurs every year in summer, but it does not happen in the lake because “the water is immense”. The two fishermen interviewed saw no health hazards in eating fish from Darbandikhan Lake, in the words of one of them: “I don’t believe eating fish from this lake causes any problems; we regularly eat fish and have not experienced any health problems ourselves.”

Farmers who live in the area where these two rivers flow to the lake could be exposed to the pollutants in the rivers, although they generally do not use the water for drinking. The local village residents use mostly ground water from wells and springs for drinking. However, the main source of irrigation is the rivers, as explained by a 30 year-old farmer: “yes, we know Tanjaro water is dirty but it is the only source for irrigating our crops, we can’t avoid it, we have no other sources for watering.” Their close proximity to the water and using this water for farming is accompanied by health concerns, including the cancer issue.

*“It is true we do not use the water of the Sirwan River for drinking, but the polluted water is dangerous for us and for our children. I think the most dangerous waste is that of Hiwa Cancer Hospital which flows to the Tanjaro River and comes directly to Sirwan River. Our livestock drink from the Tanjaro water causing destruction of their*

*lungs and kidneys and they die and if we eat the meat of these animals we also fall ill.”*

The farmers are also concerned about the waste of the main Slaughterhouse of Sulaymaniyah in Qaragol and the dead animal corpses which are thrown into Tanjaro River. Their main other health concern, in addition to cancer, seems to be skin diseases as a farmer stated:

*“Our air is clean because we are far from the garbage disposal site, but water of the river is very filthy because the waste of the Qaragol slaughterhouse drains into the Tanjaro which directly comes to the Sirwan River. People throw the corpses of dead animals into the Tanjaro which causes more pollution to the river causing the spread of many diseases and the spending of lots of money.”*

Throughout its course to Darbadikhan Lake, the Tanjaro River is polluted by sewerage from Sulaymaniyah and a number of district towns, by leachate from the Sulaymaniyah solid waste site, by industrial waste from hundreds of small and medium-sized factories, by waste from the main slaughter houses and from pesticides and fertilizers from surrounding farms. Darbandikhan Lake needs extensive research to investigate for the presence of potentially toxic elements and compounds in the water, the lake bed and the fish population of the lake. Protection of the lake from these sources of pollution should be a priority and measures should be taken as soon as possible to separate the pollution sources from the river. The provision of safe drinking water to the people of Darbandikhan is another issue of concern. Surface water, even water that is not exposed to as much pollution as Darbandikhan Lake, requires filtration in addition to chlorination before pumping it to households. However, it should also be noted that even filtration will still not totally isolate some potentially toxic elements.

## 5. Conclusions and Recommendations

Environmental pollution in and around Sulaymaniyah city is caused by a variety of factors including untreated wastewater, contaminated agricultural fields, untreated solid waste, industrial waste and contamination of the Tanjaro River and subsequently Darbandikhan Lake with all kinds of potentially toxic waste. There is a lack of clear policies and regulations to protect the environment from potential pollutants and other actions and practices that might contribute to or exacerbate the environmental pollution and related health problems. The relevant governmental authorities are not sufficiently financed, equipped and empowered to tackle the problem. The highly polarized political system is driven by partisan interests and short-term gains rather than quality standards and long term policies and regulations which are essential for environmental protection and protection of the population from exposure to environmental pollutants. Officials and local residents are aware of the problem and are concerned to some degree about the immediate and long-term health and environmental consequences of neglecting environmental pollution problems. There is a need for urgent action at all levels. Some of main recommendations, based on the assessment findings and conclusions, are listed below:

1. Strengthening governmental and professional institutions working on protection and monitoring of the environment. The Board of Environment has departments in major cities. However, they currently do not seem to be fully prepared and need strengthening in professional and organizational terms to address all issues related to environmental protection and pollution.
2. Monitoring and responding to environmental health hazards requires involvement of the health organizations. Environmental and occupational health deserve a separate section under the Department of Health, with a clear mandate to regulate and monitor environmental and occupational health issues, identify problems and guide and lead the public health response. The current infection control unit in the Department of Health does not and cannot lead that effort.

3. Generally, there is lack of necessary policies, regulations and guidelines in all sectors and at all levels in relation to safe and environmental-friendly operations in agriculture, industry, energy, transportation and other public services. However, enforcement is another problem. Even existing regulations are not properly enforced and there is need to empower law enforcement authorities to apply the rules fairly and consistently, and without discrimination.
4. Environmental protection and promotion of environmental health requires good governance and fighting corruption. The highly polarized and politicized environment and uncontrolled pursuit of profit by some influential people, coupled with lack of environmental protection polices, regulations and guidelines makes it extremely difficult for the relevant governmental departments to achieve high environmental quality and safety standards in the operation of various public and private sectors.
5. In relation to drinking water in Sulaymaniyah, the quality is generally fine but there are problems of irregular, interrupted and insufficient water supply to households that could compromise the cleanliness of water at the household level. Strengthening water management in relation to maintaining quality, observing regular water distribution schedules and equitable supply to all residents of the city could serve as an immediate solution, along with infrastructural developments. In addition, further steps should be taken to protect sources of water from contamination at the source (e.g., Dukan Lake and Sarchinar), at various points of the distribution system, especially at the points of collection and delivery.
6. In relation to wastewater disposal and treatment, the ultimate solution is establishment of sewerage treatment plants (for liquid wastes) and recycling of the sewerage as well as much of the solid waste. Meanwhile, surveying all of the networks, small and large, and their GIS mapping, are an essential organizational

undertaking which would be useful for any future plans in relation to expansion, maintenance and management of a high quality functioning sewerage treatment system for Sulaymaniyah City.

7. A major immediate problem for the environment of Sulaymaniyah City is the solid waste disposal system and the ultimate solution must include an effective comprehensive recycling program. In the meantime, the situation should not continue as it is now; a new controlled sanitary landfill area should be identified, developed and put into use, in a location far away from the Tanjaro River and in an area not vulnerable to leachates, flooding and drainage to populated areas or to water sources, including the Tanjaro River. Stricter guidelines and enforcement of proper procedures for solid waste collection, disposal and landfill. Action needed also include reduction of garbage production at all levels; segregation of the most hazardous waste materials, especially those containing heavy metals and separate disposal of hospital medical waste from municipal waste.
8. The Tanjaro River and Darbandikhan Lake are exposed to pollutants of all kinds, including wastewater, solid waste, industrial pollution and agricultural pollution. Immediate measures should be taken to prevent pollution of the river by taking those sources of pollution away from the river until a more permanent, sustainable and effective solution is found. For example as mentioned above moving the garbage disposal landfill area farther away from the river, and banning the disposal of industrial waste and other major pollution sources (e.g. slaughterhouses) from being dumped into the river.
9. There are an unknown number of oil extraction sites and refineries in the governorate that could also be a serious reason for concern on environmental pollution. These potential pollution sources might need to be considered in future studies.

10. Industrial activities are poorly regulated and monitored in terms of environmental and occupational safety operations and standards. Licensing and monitoring procedures might need to be reviewed and strengthened, with emphasis on reduction and control of environmental pollutants and enforcing safety regulations.
11. The importation, marketing and use of pesticides and fertilizers for agricultural activities are also poorly controlled and regulated, which contribute to detrimental environmental health effects due to soil, water and plant contamination in the affected areas. Relevant commercial and agricultural authorities should be empowered to strengthen control of the use of these products to make sure they meet health and environmental standards and that they are appropriately licensed imported products and are properly distributed and used correctly by the farmers. Farmers should be supported and guided to safely use only licensed products and to wear personal protective equipment when required.
12. Studies should be conducted of chemical and biological contaminant levels in local agricultural products, including fruits, vegetables and domestic animals, as well as in the fish population of Darbandikhan Lake, especially in residential, industrial and agricultural areas around the City sewer channels and the Tanjaro River.
13. Using Sulaymaniyah wastewater for farming must be prohibited by law and enforced. Until measures are taken to protect the river from pollution, farmers around the river should be provided with proper guidance and health awareness on safer farming practices, wearing personal protective equipment and personal hygiene.
14. Contamination of the food chain around Sulaymaniyah City and the Tanjaro River with potentially toxic elements and compounds is a major concern because of the observed persistence of the contaminants in soil even after elimination or cessation of the source of pollution. This issue should be taken seriously by health professionals, relevant local authorities and political leaders since the solution to

this problem is not easy and requires sustained and multi-disciplinary efforts at all levels.

15. People living in the vicinity of the Tanjaro industrial zone and major factories and other pollution sources are most aware and probably most affected by the pollutants. Therefore, any socially responsive and equity-focused program for mitigation of the environmental health hazards should involve these vulnerable populations throughout the assessment, planning and implementation stages.
16. Quality control of marketed food is generally not well-developed and regulated. Supervision and control of locally produced and imported food stuff and agricultural products, development of policies and regulations and their enforcement should be made a priority.
17. Protection of Darbandikhan Lake from major sources of pollution should also be made a higher priority by the lake management team and other relevant authorities, and measures should be taken as soon as possible to isolate and minimize major pollutants of the lake
18. Darbandikhan Lake needs extensive and sustained research on its water quality and biology to monitor the presence and effect of potentially toxic elements and other pollutants, and to identify source of environmental health problems, the impact of lake pollution on the health of human and fish populations, and to propose feasible and effective solutions to any environmental problems that are identified in the research conducted.
19. Provision of safe drinking water to the people of Darbandikhan should be made an urgent priority. This can be achieved in part by building through proper water treatment plant including filtration and chlorination. Regular monitoring of the quality of water provided to households, especially in relation to heavy metal contamination and harmful microbial content is required.

20. Establishment of a continuous research effort is needed on the topic of environmental pollutants in and around Sulaymaniyah City and the Tanjaro River, in order to periodically quantify and monitor levels of various environmental contaminants in water, soil, plants and air.
21. Undertaking epidemiological studies on the populations living in the vicinity of major sources of pollution is needed to investigate potential short-term and long-term health effects of human exposure to environmental hazards.
22. Communication strategies including advocacy and social mobilization should be developed and implemented using various mass media, group and one-to one communication channels to promote public awareness on environmental health risks, encourage healthy practices at the individual level, advocate for healthy public policies, and create an empowering environment where environmental protection becomes an issue of national concern and responsibility.
23. The current regional conflict, influx of refugees and IDPS, and the economic and financial crisis in the Kurdistan Region during the past few years have resulted in deterioration of all public services. The potentially detrimental impact on these factors on the region has probably aggravated the environmental situation and should be studied in more detail as well.

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