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Risk Chemical Waste And Environmental Pollution By Wastewater From The Station Sana'a – Yemen

Essam Abdullah Muharram*, Cimpeanu Mihai Sorin, Riyad Ismail*****

** Essam Abdullah Muharram University of Agronomical Sciences and veterinary medicine of Bucharest-Faculty of Reclamation and environmental engineering, Bucharest, Romania.*

***Univ. Prof. CimpeanuMihaiSorin, University of Agronomical Sciences and veterinary medicine of Bucharest-Faculty of Reclamation and environmental engineering, Bucharest, Romania*

****Dr. Riyad A. M. Ismail, University of Sanaa – Faculty of Engineering, Department of Fundamental engineering science, Sanaa, Yemen*

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E-mail: muharram75@gmail.com;

Abstract

This paper studies the impact that wastewater treatment stations in Yemen have on the environment and society, the high degree of pollution and the lack of concern of the authorities in this regard. It goes on to list the characteristics of the natural environment in which the wastewater treatment plant located in the capital Sana'a operates, as well as the areas surrounding that territory. The area's specific climatic conditions - warm and dry - make treatment plants for large cities a necessity, and the use of wastewater in agriculture for irrigation and of sludge as fertilizers. This location was chosen for the study as it is located in a heavily populated area, in the vicinity of which farming takes place, and because it is an area with significant historical sites of major tourist interest. The following presents the study materials and methods used. For the conduct of the study we have worked in collaboration with a group of specialists in the field, with representatives of local and central authorities and with citizens residing in the area. We have set the perimeter within which samples were taken for analysis and the area of investigation of the environmental impact by means of questionnaires. We have used the instruments and equipment found in the treatment stations' laboratories at Sana'a University - Faculty of Agriculture and those of the National Laboratory for Water and Environmental Quality Control. Chemical, physical and microbiological analyses were conducted in these laboratories following specific methodologies, and the results were analyzed and interpreted in accordance with the objectives of the study. It presents the results of the field analyses, in which questionnaires filled in by the local community were used, and the results of the chemical and biological analyses carried out on different wastewater samples from different sources. The analyses were performed in the station's laboratory according to the standards and specifications in force. The study found that negative results were prevalent if high proportions of Sr, Ni, Pb, Cu, Co, Cd, Zn were shown. These results largely explain the phenomenon of environmental pollution and presents conclusions and recommendations for considerable improvements to the existing situation.

Keywords : Chemical Waste Water; Environmental Pollution; Wastewater.

1. Introduction :

The environmental impact assessment [1, 2, 3] is a study that can be used to improve the decision-making process and ensure that the development options under consideration are environmentally, socially [4,5] and health friendly [6], as well as economically sound and sustainable. It is concerned with the identification, evaluation and estimation of the foreseeable impact types, both beneficial and harmful, of proposed development projects, but also of alternatives to them. It aims to eliminate or reduce the negative impact, optimize positive impact through mitigation and improvement measures (Institute of Resource Assessment (1995). The EIA refers to a process, rather than to a specific activity, the environmental impact study itself being only a part of the process [7].

There is an extensive but incomplete body of scientific knowledge on the impacts of chemicals and wastes on humans and the environment [8]. Chemicals play an important role in human life, economic development and prosperity, yet they can also have adverse impacts on the environment and human health.

It was said that heavy metals in most cases are accumulated in the crop, and could adversely affect consumers feeding on these crops especially group of heavy metals which have been shown to create clear health hazards when taken up by plants [9,10]. Also vegetables are known to be good absorber of heavy metals from the soil [11,12]. The danger lies in its ability to accumulate in the bodies of local residents. [13].Human and animal need a certain percentage of these elements that might happen on the part of the plant through the food chain [14]. The accumulation of heavy metals and metalloids in agricultural soils is of increasing concern due to the food safety issues and potential health risks as well as its detrimental effects on soil ecosystems [15]. An inventory of heavy metal inputs (As, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sr, V, Zn) into agricultural soils in different countries [16]. Nicolson concluded that one of the main sources of these materials are sewage sludge and industrial wastes. This work will assist in quantifying those heavy metals and present recommendations to develop strategies for reducing heavy metal inputs into agricultural land and effective policies aimed at protecting soils from long-term heavy metal accumulation, to protect human life.

One of the main threats comes from the element Strontium, as the human body absorbs strontium as if it were calcium. Due to the chemical similarity of the elements, the stable forms of strontium might not pose a significant health threat, but the radioactive 90 Sr can lead to various bone disorders and diseases, including bone cancer.

2. Materials and methods used:

The EIA study focuses on the district of Bani Al-Harith in Sana'a-Yemen, (Figure 1) that represents the environment in many conditions. This large area is located above sea level and is surrounded by agricultural valleys and residential areas in the vicinity of the capital Sana'a, about 25 km away from the city center. The environment and agricultural crops are varied and include vegetables such as tomatoes, cabbage, onions, potatoes, etc. and fruit such as grapes, figs, pomegranates and almonds, and berry bushes.

During the summer, the crops are irrigated and greenhouses are used during winter. The average temperatures in summer fall between 18-30°C, and humidity reaches 55% due to the rainfall during this time of year. In Yemen, summer is the season with the highest agricultural impact for the region. During winter, temperatures range between 3 and 12°C and the relative humidity reaches 35%, during this season rain being rare or non-existent and the use of irrigation facilities is different depending on the season.

Figure 1. Bani al-Harith in Sana'a-Yemen

We collected samples for analysis in the Laboratory of Standardization and Metrology using different tools of different materials and shapes, namely plastic, glass, but also using protective plastic suits (Figure 2). We have interviewed the target group of this study, numbering 97 persons, with the purpose of finding the most important areas and types of production in the area, but also the degree of pollution and its effects on the environment.
The study covered the following areas:

Biate Snohob - Bani al-Harith - Wade Ahmed

Questionnaires were distributed to citizens in order to gather information to study the effects of sanitation, the economic environment, the historical and social impact of the plant on the local community and on their homes.

Figure 2. Taking the samples for analysis

This is due to the fact that we are addressing the largest wastewater treatment station and the biggest market for agricultural products which are not under the supervision of any epidemics and disease spread prevention supervisory body. Thus, with the help of monitoring carried out by means of GPS equipment, several visits were carried out in the areas corresponding to supply wells, taking samples of contaminated water, well water and crop samples. All these samples were the basis for the physical, chemical and biological tests, also measuring the amount of heavy substances present within them.
We analyzed the samples at the sewage plant of the Ministry of Water and the Environment, located near the Sanaa International Airport.
Another set of samples was sent to the General Authority for Standardization and Metrology in order to analyze and measure the quantities of heavy metals in the samples taken from the area of study in order to measure the extent of pollution. The following presents only working materials and methods.
This institution is responsible for the supervision of analytical procedures of the biological and chemical samples, and measuring the proportion of COD and BOD.

2.1. Materials and tools used for laboratory analyses

Physical, chemical, biological and microbiological analyses are carried out within the processing laboratories. Tests are carried out on raw, decanted and filtered water. Water quality is permanently monitored via on-line analyzers. The staff is made up not only of chemists but also biologists, lab assistants and microbiology inspectors, which determine treatment reagents’ dosages. The biology and microbiology laboratories mainly deal with the analysis of phytoplankton and zooplankton in the water which is to be supplied to citizens. The Apa Nova laboratories have the only device for the determination of the existence of protozoa, giardia and cryptosporidium. It aims to identify polyform bacteria, enterococci, germs from raw as well as filtered/treated water.

2.2. Method of operation

Methods used in the analysis of wastewater characteristics:

Physical and chemical analyses:

Water pH interaction was estimated directly using the pH-meter device. Electrical conductivity was determined using the EC-meter device.

The Maekero Kaldal ammonium ions were estimated using the described device according to method [17]. After estimating the ions from the ammonium nitrate reductase, magnesium oxide MgO was used. The Kaldal device was used for analyses in accordance with [17].

pH value (pH):

It is necessary to measure the pH of raw water where an adequate biological treatment range is from 5/6 to 5/8, because any change to this value leads to a lack of activity of bacteria and a lack of treatment effectiveness. The pH value of the water entering the installation is modified by the interference of this water with industrial waters, thus the location where this phenomenon occurs must be found and it must be prevented. The spread of this modified water into the sanitation network must also be prevented. The electrometric value shall be determined according to the pH value of standard water by means of the pH-meter This test is performed daily in raw water tanks, where water ventilation and treatment take place.

Material mixture solid suspensions (MMSS)

We have determined the proportion of sludge in the aeration tank and treatment system and by using this test we know the value of the quantity of sludge to be removed from the system. This test provides information about poor ventilation of water from drying pools, at a temperature of 105 °c. The weight of the suspended solids contents per liter is also determined, as well as the amount of sludge that is found in the system at a certain time. The test is carried out on a daily basis.

. Statistical Analysis of the Results

The analysis of the data and information contained in this study were conducted using:

- chemical analysis of the samples (As, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sr, V, Zn)

3. Chemical Analyses' Results

The results of the chemical analysis (Table 1 and Figure 3.) show that, in the water samples taken from the population's wells, located near the station and drilled to a shallow depth (20 to 60 meters), the chemical element content is above standard in most cases.

Water samples

Results summarized in Table 1, indicate that concentrations ppm (mg/L) of heavy metals in wastewater channel were highest for the Cu, Pb followed by Fe, Co, Sr, Ni, Zn, Cd and Mn. However, heavy metals concentrations in groundwater higher the permissible limits of FAO [9,18],Pint [19] Row and Abdel-Majid [20]. Same detection was also obtained by Rattan et al., [21] and Singh et aL, [22] who have found higher concentrations of heavy metals in sewage effluents when compared to the ground water. As well Sr. showed very high in samples. It's known that Pb, Cd, Sr elements are a toxic and has been considered one of a noxious elements carcinogens which cause lung carcinoma when is exposed to substantial concentrations [18].Then, it is often found in waste plants dyes, plastic and rubber factories, electrical panels and batteries [20]. The concentration increase of these elements in the water sources happened as a result of contamination with canal wastewater across the region. This result indicates that the use of this water for irrigation purposes could expose population to dangerous healthy risks and could damage the environment [23].

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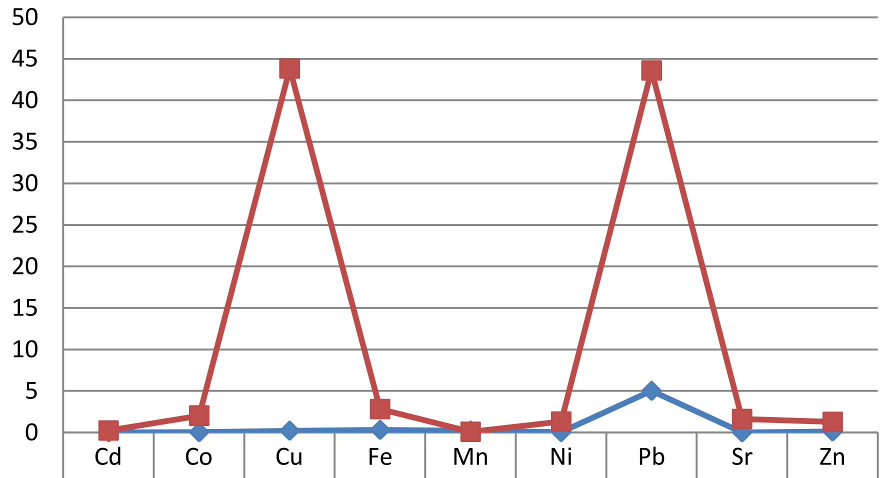
[11,12]. The danger lies in its ability to accumulate in the bodies of local residents. [13]. Human and animal need a certain percentage of these elements that might happen on the part of the plant through the food chain [14]. The accumulation of heavy metals and metalloids in agricultural soils is of increasing concern due to the food safety issues and potential health risks as well as its detrimental effects on soil ecosystems [15]

Table 1. Chemical analysis' results

Element	Standard (allowed limit) ppm*	Resulting value ppm**	Difference in %
As	0.1	-	
Cd	0.01	0.23919	24%
Co	0.02	2.0257	101%
Cr	0.01	-	
Cu	0.2	43.823	219%
Fe	0.3	2.823	9%
Mn	0.2	0.0795	0%
Mo	0.01	-	
Ni	0.02	1.295	65%
Pb	5	43.61	9%
Sr	0	1.6246	
Zn	0.1	1.277	13%

* WORD BANK Group 1998 General Environmental Guidelines. Pollution Prevention and Abatement Handbook.
** Obtained results



	Cd	Co	Cu	Fe	Mn	Ni	Pb	Sr	Zn
Standard (Limita admisa) ppm*	0.01	0.02	0.2	0.3	0.2	0.02	5	0	0.1
Valoare rezultata ppm**	0.23919	2.0257	43.823	2.823	0.0795	1.295	43.61	1.6246	1.277

Figure 3. Chemical analysis' results

Sample 6 (Samp) **4/28/2013, 7:40:41 AM** **Rack 1, Tube 6**
Weight: 1 **Volume: 1** **Dilution: 1**

Label	Replicates Concentration		
As 188.980	-0.064697u	0.016477	0.043892
Cd 214.439	0.019499	0.033283	0.018974
Co 238.892	0.200973	0.201539	0.203659
Cr 267.716	0.011663	0.009438	0.007121
Cu 327.395	4.34570	4.40233	4.39904
Fe 238.204	0.282505	0.284736	0.279331
Mn 257.610	0.008559	0.007929	0.007390
Mo 202.032	-0.006461u	0.009401	0.028897
Ni 231.604	0.120532	0.150448	0.117626
Pb 220.353	646.880x	655.384x	652.820x
Sr 407.771	0.160996	0.162588	0.163810
V 292.401	0.006215	0.004781	0.006087
Zn 213.857	0.128000	0.128349	0.126823

Label	Sol'n Conc.	Units	SD	%RSD	Int. (c/s)	Calc Conc.	IS
As 188.980	-0.001443uv	mg/L	0.056469	3913.8	1.54320	-0.001443 mg/L	-
Cd 214.439	0.023919	mg/L	0.008114	33.9	9.22075	0.023919 mg/L	-
Co 238.892	0.202057	mg/L	0.001416	0.7	137.930	0.202057 mg/L	-
Cr 267.716	0.009407	mg/L	0.002271	24.1	10.8972	0.009407 mg/L	-
Cu 327.395	4.38236	mg/L	0.031789	0.7	34860.0	4.38236 mg/L	-
Fe 238.204	0.282191	mg/L	0.002716	1.0	258.664	0.282191 mg/L	-
Mn 257.610	0.007959	mg/L	0.000585	7.3	58.2132	0.007959 mg/L	-
Mo 202.032	0.010612uv	mg/L	0.017710	166.9	3.37259	0.010612 mg/L	-
Ni 231.604	0.129535	mg/L	0.018169	14.0	29.0872	0.129535 mg/L	-
Pb 220.353	-x	mg/L	4.36199	0.7	73395.1	- mg/L	-
Sr 407.771	0.162465	mg/L	0.001411	0.9	107070	0.162465 mg/L	-
V 292.401	0.005694	mg/L	0.000794	13.9	3.51070	0.005694 mg/L	-
Zn 213.857	0.127724	mg/L	0.000800	0.6	110.996	0.127724 mg/L	-

Label	DF
As 188.980	1.00000
Cd 214.439	1.00000
Co 238.892	1.00000
Cr 267.716	1.00000
Cu 327.395	1.00000
Fe 238.204	1.00000
Mn 257.610	1.00000
Mo 202.032	1.00000
Ni 231.604	1.00000
Pb 220.353	1.00000
Sr 407.771	1.00000
V 292.401	1.00000
Zn 213.857	1.00000

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Mn 257.610	0.007959	mg/L	0.000585	7.3	58.2132	0.007959 mg/L	-
Mo 202.032	0.010612uv	mg/L	0.017710	166.9	3.37259	0.010612 mg/L	-
Ni 231.604	0.129535	mg/L	0.018169	14.0	29.0872	0.129535 mg/L	-
Pb 220.353	-x	mg/L	4.36199	0.7	73395.1	- mg/L	-
Sr 407.771	0.162465	mg/L	0.001411	0.9	107070	0.162465 mg/L	-
V 292.401	0.005694	mg/L	0.000794	13.9	3.51070	0.005694 mg/L	-
Zn 213.857	0.127724	mg/L	0.000800	0.6	110.996	0.127724 mg/L	-

Label	DF
As 188.980	1.00000
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Cu 327.395	1.00000
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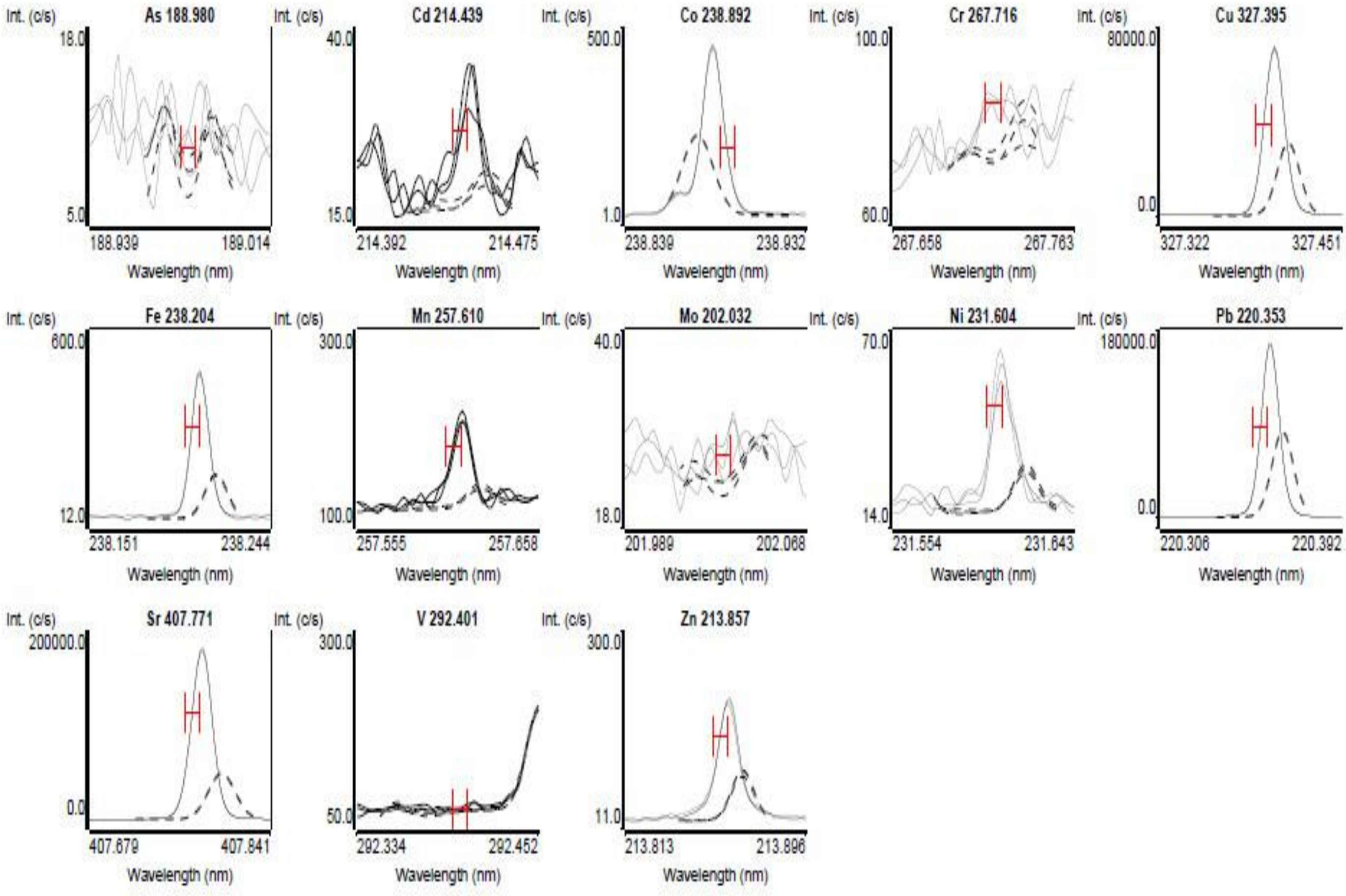
Mn 257.610	1.00000
Mo 202.032	1.00000
Ni 231.604	1.00000
Pb 220.353	1.00000
Sr 407.771	1.00000
V 292.401	1.00000
Zn 213.857	1.00000



$$\text{Cd} = \frac{0.023919 \text{ x}50}{5} = 0.23919 \text{ ppm}$$

$$\text{Co} = \frac{0.202057 \text{ x}50}{5} = 2.02057 \text{ ppm}$$

$$\text{Cu} = \frac{4.38236 \text{ x}50}{5} = 43.8236 \text{ ppm}$$

$$\text{Fe} = \frac{0.28236 \text{ x}50}{5} = 2.8236 \text{ ppm}$$

$$\text{Mn} = \frac{0.007959 \text{ x}50}{5} = 0.0795 \text{ ppm}$$

$$\text{Ni} = \frac{0.129535 \text{ x}50}{5} = 1.29535 \text{ ppm}$$

$$\text{Pb} = \frac{4.361 \text{ x}50}{5} = 43.61 \text{ ppm}$$

$$\text{Sr} = \frac{0.162465 \text{ x}50}{5} = 1.62465 \text{ ppm}$$

$$\text{Zn} = \frac{0.127724 \text{ x}50}{5} = 1.27724 \text{ ppm}$$

1 liter of water for analysis was taken the Bait Haroon treatment station. Sample collection was carried out with the help of specialized operators, at a distance of 500 m from the station.

The detected elements (Cd, Co, Cu, Fe, Mn, Ni, Pb, Sr, Zn) cadmium, cobalt, copper, iron, manganese, nickel, lead, strontium and zinc also show different percentage values as per Table 2, some of these values exceeding allowed limits (via IPC equipment), the highest pollution being caused by the presence of heavy elements with different provenance, from waste water in the case of crops up to industrial residues (IPC).

Table 2.The strontium, cadmium, cobalt, copper, iron, manganese, nickel, lead and zinc elements Sample No.6

Element	Resulting value ppm**	Allowable limit ppm*	Comments
Cd	0,23919	0.01	The amount of Cadmium Cd present in the sample taken from vegetables is clear, it shows a very high value (0.23919) compared to the allowed value of 0.01
Co	2.0205	0.02	The amount of cobalt Co present in the sample taken from vegetables is clear, it shows a very high value (2.0205) compared to the allowed value of 0.02
Cu	43.82	0.2	The amount of copper Cu present in the sample taken from vegetables is clear, it shows a very high value (43.82) compared to the allowed value of 0.2
Fe	2,8236	0.3	The amount of iron present in the sample taken from vegetables is clear, it shows a very high value (2.8236) compared to the allowed value of 0.3
Mn	0,0795	0.2	It is obvious that analysis of Mn present in the vegetable samples taken, of 0.0795, is closer to the allowable limit, reaching the value of 0.2 ppm.
Ni	1.29535	0.02	The amount of nickel Ni present in the sample taken from vegetables is clear, it shows a very high value (1.29535) compared to the allowed value of 0.02
Pb	43.61	5	The amount of lead Pb present in the sample taken from vegetables is clear, it shows a very high value (43.61) compared to the allowed value of 5
Sr	1.6246	-	It is assumed that this element does not exist in Yemen, since there are no specifications either here or in other countries, except Saudi Arabia, where we can talk about a limit for this element in sea water, equal to (8ppm), considering that the source consists of petroleum waste that pollutes the water; in Yemen we consider that we are dealing with the same phenomenon due to pollution by insecticides and chemicals used in farming to combat insects such as flies and mosquitos, as well as industrial waste found in wastewater.
Zn	1.277	0,1	The amount of zinc Zn present in the sample taken from vegetables is clear, it shows a very high value (1.277) compared to the allowed value of 0.1

* WORD BANK Group 1998 General Environmental Guidelines. Pollution Prevention and Abatement Handbook.

** Obtained results.

Conclusions

In Yemen there are no legislative norms concerning potable water, nor for irrigation water. Standards used in Yemen are the standards of FAO and WHO.

As part of the study in this thesis, samples taken from six wells show that they are on the uppermost limit in terms of microbiological and chemical saturation, but in some cases these values are exceeded.

The majority of contaminations are caused by the lack of wastewater treatment stations which are located near wells. The treatment station projects were modified after their execution, because of a dire necessity to accommodate larger quantities to increase capacity accordingly to keep pace with the region's development.

The absence of regulations and policies permits water found in pools and sewage waste to be used in agriculture, without any prior treatment.

This study found that the ratio of heavy elements greatly exceeds international standards, as shown in Table (1). One of the main concerns is the Sr element which should be present in very low to null amounts, as it is considered one of the main causes of health (Bone Cancer) problems in the area of study.

The impact caused by the presence of the wastewater treatment station upon human health was negative, causing respiration problems, eye inflammation and skin sensibility ...... etc., and as a result a large number of people began migrating out of the affected areas.

Considering these results, we can concluded that using wastewater or polluted water sources without adequate safeguards draw attention to several issues. There is existing of optimize in soil properties with raising of Organic Matter and decries of pH unit but on the other hand there is persistence of the contamination in local environment with several element (Sr, Cd, Co, Cu, Fe, Mn, Ni, Pb, Zn) such as in the soil irrigated with wastewater which led to potential health risks for farmers and consumers alongside environmental actual risks.

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