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Risk Assessment of Wastewater, Environmental and Biological Pollution Reduction in Yemen

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Abstract

This paper studies the impact that wastewater treatment stations in Yemen have on the environment and society, the high degree of biological 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.Biological, 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 physical 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. These results largely explain the phenomenon of environmental pollution and presents conclusions and recommendations for considerable improvements to the existing situation.

Keywords : Waste Water; Risk; Pollution; biology

1. Introduction :

The environmental impact assessment [1-3] 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 [8-12]. 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.

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

A number of materials, equipment and equipment were used to analyze the collected samples, as follows:

- GPS equipment (Apple) was used to measure distances and to identify points of pollution, but also to gather samples from within the study area, this being the area with the largest expanse of pollution caused by sewage.
- The different areas exhibiting various levels of environmental contamination were photographed (Figure 2).

Figure 2 Different areas of different pollution levels

- Questionnaires were distributed to target groups in order to collect information concerning the contamination and damage caused by the plant to the environment, soil, animals and people (Figure 3).

2.1. Biological analysis:

Determining the presence of bacteria (MPN):

The need for this test arises in order to determine the effectiveness of the sterilization process, as well as the availability of a standard quantity of water. This test is conducted by placing a number of dilutions in cascade, especially to highlight the growth of E. coli, such as in the EULER Treptuz (Lauryl TryptoseBroth) medium or in the pipe environment (environmental analysis of a aMacConkeyMacConkey broth), and the tubes containing other Durham tubes are incubated upside-down at a temperature of 35-37°C for 24 hours. If any gas content is detected in the tubes, it is deemed that, in these tubes, the test result is positive. The rest of the Vtturk-type pipes are left for another 24 hours to obtain confirmation then scanned again. The tubes are delineated, testing is performed and then compared to standard values. This test is performed at least once a week.

In order to carry out the analyses, the following steps were taken:

- the weight of a standard cleaning and complete drying of the cup;
- filling the flask with water at a moderate temperature until the solution reaches the bottom of the concavity, and then reaches the neck of the volume flask;
- leaving it to settle for 5 minutes;
- the standard weight of the cup, together with the water content;
- use of an amount of water of different weight;
- Calculation of the data in the table was carried out using the correct size flask.

Calibration has been performed several times, then average size and standard deviation value were calculated. Subsequently, the sample analysis step was performed by injecting the sample into a ICP device to measure heavy substances.

At the end, the results were collected from the Laboratory of Standardization and Metrology.

2.2. Statistical Analysis of the Results

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

- the descriptive analysis of various questionnaires;
- analysis of the data and information obtained through questionnaires using SPSS
- physical analysis of samples; (color-electric conductivity, pH, smell, total dissolved solids (EC x 0.65), turbidity after filtration, calcium, magnesium, chloride, nitrate, potassium, sodium, total CaCO3 strength).
- biological analysis of samples (COD organic substance, total Coli organisms, Coli organisms from feces, BOD5, TSS)

The SPSS software and electronic charts were also used.

3. Experimental Results

The data in Tables 1 and 2 and Figure 5 and 6 indicates that the total number of questioned persons is 97. Most of the respondents stated that wells were dug during 1983-1993; over one third stated they were created during 1993-2003 and only 9 of them were drilled over the past 10 years. Most wells are within 500 meters of the stations' drying ponds and cease to appear at a distance of 1000-2000 m.

The laboratory data indicate that soil fertility reaches values which are poor, medium and equal in proportions, and only 9 of the respondents consider the value of the samples to be superior.

The frequencies and percentages for each separate paragraph according to the computerized statistical data results are as follows:

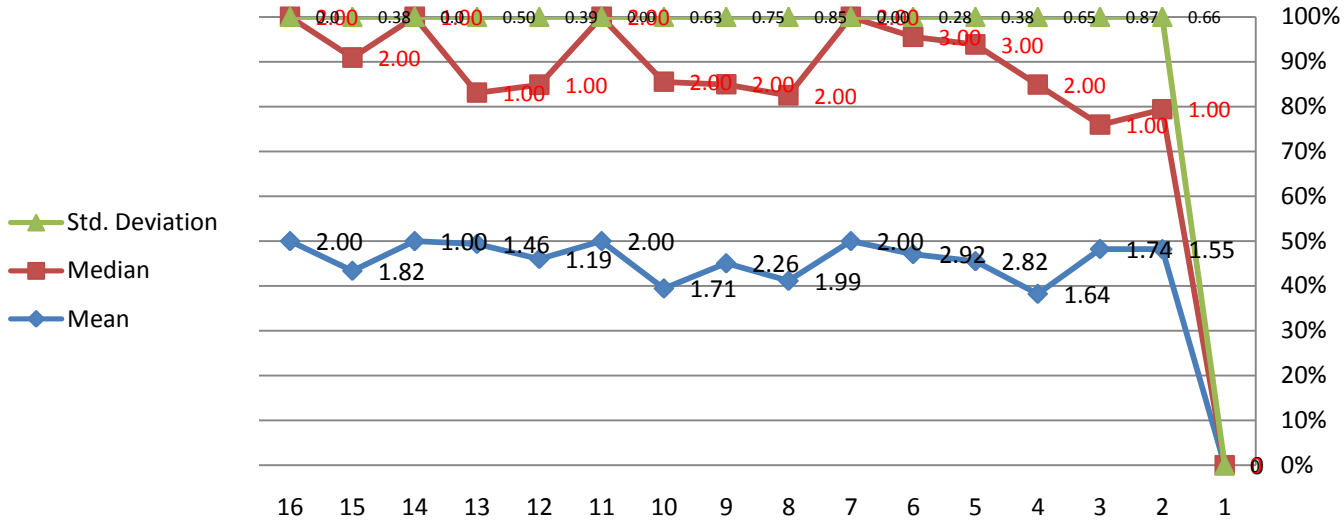

Figure 3. The first area that includes answers to tripartite requirements questions and obeys statistical analysis standards

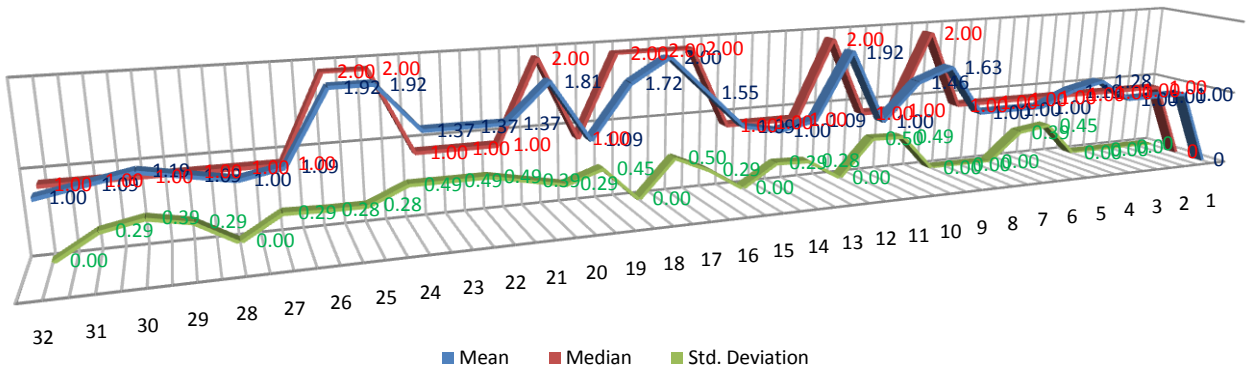

Figure 4 A second area, which includes answers to bipartite questions, same requirements and obeys standards of statistical analysis

Statistics processed by researcher

1. Discussion:

1.1.Through referendum result.

It became clear that most of the wells from which samples were taken are old wells which were drilled during the period between 1983 and 1993, their percentage being 54,6%, but 36,190 of them were drilled during the period between 1993 to 2003, and 9,3% of them were drilled between the years (2003- 2013).These wells are always in operation and the pumped quantity cannot change or convey (decrease), but indicates direct feeding to wells from the wastewater coming from the station.

Most of these wells are not far from the station or from sewage water,being located only a short distance of not more than 500 m to 2000m away, a very close distance, and 53,6% of them located at a distance of 500m from the sewage channel.The water in the wells is used to irrigate the agriculture crops in the area, most of which are vegetables, especially (cabbage-onions – potatoes).These crops are also irrigated by direct floodingwhich pollutes these crops with a large number of germs; the workers and famers also suffer as a consequence.

Table 1. The first area that includes answers to tripartite requirements questions and obeys statistical analysis standards

:		drilling of wells	Well site and the environment	Soil fertility	The amount of gas and odor emissions	Km variables over Tatherkm	What are the sources of water used in agriculture in your area. After the establishment of the station	How much drinking water is consumed monthly per capita?	What is the value of drinking water consumption per capita?	What is the average income per family in this region?	Do you mix soil with a compost mixture	What is your education level	Residence	The number of hospitals or medical clinics	What is the economic impact of farming in the region	The use of sttion water for crop irrigation	Averages
N	Valid	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Mean		1.55	1.74	1.64	2.82	2.92	2.00	1.99	2.26	1.71	2.00	1.19	1.46	1.00	1.82	2.00	1.87
Median		1.00	1.00	2.00	3.00	3.00	2.00	2.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	1.80
Std. Deviation		0.66	0.87	0.65	0.38	0.28	0.00	0.85	0.75	0.63	0.00	0.39	0.50	0.00	0.38	0.00	0.42
Percentiles	25	1.0000	1.0000	1.0000	3.0000	3.0000	2.0000	1.0000	2.0000	1.0000	2.0000	1.0000	1.0000	1.0000	2.0000	2.0000	
	50	1.0000	1.0000	2.0000	3.0000	3.0000	2.0000	2.0000	2.0000	2.0000	2.0000	1.0000	1.0000	1.0000	2.0000	2.0000	
	75	2.0000	3.0000	2.0000	3.0000	3.0000	2.0000	3.0000	3.0000	2.0000	2.0000	1.0000	2.0000	1.0000	2.0000	2.0000	

Table 2. A second area, which includes answers to bipartite questions, same requirements and obeys standards of statistical analysis

		Do you observe environmental changes from one year to another due to the presence of the station?	Does Ttatron waste come directly from the station?	Have animals or humans become ill as a result of the station's activity?	Is population migration influenced by the station?	Are you satisfied with the involvement of the local community in the issues caused by the station in the region?	Are there any health and safety procedures for personnel working in the field?	Are there any plans which are contingent on the station?	Is there cooperation or coordination at the station level between the population and station management?	Is everyday life based on agricultural and animal production? the total	Is compost used in agriculture?	Are safety procedures used for fertilization and water?	Are projects in the area harmful to the environment?
N	Valid	97	97	97	97	97	97	97	97	97	97	97	97
	Absent	0	0	0	0	0	0	0	0	0	0	0	0
Medium		1.00	1.00	1.00	1.28	1.19	1.00	1.00	1.00	1.63	1.46	1.00	1.92
Median		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	2.00
Standard deviation		0.00	0.00	0.00	0.45	0.39	0.00	0.00	0.00	0.49	0.50	0.00	0.28
Percentage	25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	2.0000
	50	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	2.0000	1.0000	1.0000	2.0000
	75	1.0000	1.0000	1.0000	2.0000	1.0000	1.0000	1.0000	1.0000	2.0000	2.0000	1.0000	2.0000
	75	1.0000	1.0000	1.0000	2.0000	1.0000	1.0000	1.0000	1.0000	2.0000	2.0000	1.0000	2.0000

Do you know the projects' environmental impact value?	Is there any environmental impact of the station to be assessed in the area?	Does the community get involved in the environmental impact assessment process?	Do you consider local authority involvement in the environmental assessment process as appropriate?	Expressing agreement with regard to the involvement of consultants in the environmental assessment process If your	Are there any hospitals or medical centers in the area? Are	Are there any emergency clinics in the area?	Are there any epidemics in the area? n	Is there an effect on tourism in the area?	Are there any effects of the station?	Have your living conditions improved after the establishment of the station	What issues have arisen after the establishment of the station?	Are there any other results due to the station?	What is the effect of the plant on drinking water?	What is the impact on the soil fertility quality and on the plant?	What is the station's impact on agricultural products ?	Do you have any stability issues in this region?	Who were the sources of drinking water before the establishment of the station?	Is station water used for crop irrigation?	
97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1.09	1.00	1.09	1.55	2.00	1.72	1.09	1.81	1.37	1.37	1.37	1.92	1.92	1.09	1.00	1.09	1.19	1.09	1.00	1.30
1.00	1.00	1.00	2.00	2.00	2.00	1.00	2.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.26
0.29	0.00	0.29	0.50	0.00	0.45	0.29	0.39	0.49	0.49	0.49	0.28	0.28	0.29	0.00	0.29	0.39	0.29	0.00	0.25
1.0000	1.0000	1.0000	1.0000	2.0000	1.0000	1.0000	2.0000	1.0000	1.0000	1.0000	2.0000	2.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
1.0000	1.0000	1.0000	2.0000	2.0000	2.0000	1.0000	2.0000	1.0000	1.0000	1.0000	2.0000	2.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
1.0000	1.0000	1.0000	2.0000	2.0000	2.0000	1.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	

Furthermore, the survey showed that 72% of the people are suffering from a lack of medical services, lack of medical centers and clinic units in the area. Also, along the sewage channel there is no monitoring unit overseeing the pollution process, and there is no emergency clinic, inspite of spreading diseases.The animals in this area aufferas a result of this station, and the percentage of those who are suffering is 81,6%. It was noticed that disease and illness spreads more readily among animals and children,this indicating a high percentage of pollution.

The survey indictates the consumption of drinking water per family is not more than 10-5 m^3 monthly, and most of the people suffer from a lack of clean water.

It indictatedthat 90,7% of people who are suffering from a lack of drinking water are forced to use special machines to carry/ bring drinking water from distant areas such as BaniHushaish, an area that has deep wells used only for drinking water, and these wells are private projects and as such citizens that are charged high prices to buy this water.This hs because the wells used for drinking water in the area concerned in study cannot be used for drinking water, as they have been polluted at different depths by the station, by station water and sewage water.

The agriculture crops grown in the area depend on irrigation from drying pools, which yields high production, and highly commercial produce which are grown in all seasons are an incentive for many farmers to maintain this occupation,as well as encouraged others to commence or expand it.

100% of the people are mixing fertilizer produced from wastewater into the agricultural soil, and as a result these crops growing well all the year round, a number of agricultural epidemics have spread, which in turn forced farmers to fight them by using chemical insecticides. The use of insecticides was random, which increased pollution, as it was done without using modern tools or protection procedures, and without any agricultureal guidance.

The treatment station and the external channel net are located in the middle of a crowded living area. The population distribution on the sides of the foundation and its channel are approximately equal in percentage between those who live in the Eastern and Southern sides,meaingabout 53.6%, and 46.4% live on the Northern side.The survey showed that 81.4% of the local community is not contentwith the presence of the station in their area unless a solution to this pollution is found.They emphasized that there is no procedure in place to protectthe workers in the fields, whether from the treatment station or from other government agencies, this agreement being by 100% of respondents.Also, there are no emergency plans or any protection for the local community from station management,in the event of any emergency which may occur at the station or in case of leaks of poor quality water causea disasterfor the community.

The study showed that 100% percentage of the population stated that there is no cooperation or arrangement between station management and the local community to e notified in the event of problems resulting from leaks of low quality water, norhave they been made aware of any method of treating or controllingwater quantity, or how to treat or to slow pollution when it occurs.

About 62.9^0% of the population depends on animals and agricultural production as a source of income and 37.1% is of agriculture in the area provides a subordinate income source.In spite of that, farmers use ardor rising from the treatment station as a fertilizer on their plantations, but they also added large amounts of the chemical fertilizer NPK to improve soil fertility and to increase production. 46.4% of the samples in this study use fertilization methods in addition to using chemical insecticides, in addition towaste water, and they don’t take into account any occupationalprotection procedures while using this chemical.

While searching for other projects in the same area which address the polluted environment, 91.8% of the population emphasized that there are no other projects found in the study area. Also the subject of environmentis absent from many of the individual samples,an evaluation of the effect on the environment not being mentioned, and 90.7% of the population, accounting for most of the local community, answered that they are not aware of any projects or information aimed at evaluating the effect on the environment, and they didn't evaluate the environmental effect since the construction of the station, and 90.7% of the population also emphasized that there is no community participation in the environment effect evaluation process for any project.

Also, 54.6% of the local communityis of the opinion that the local community must be made aware of the environment effect evaluation process and 100% of the community whishesto press for participating in consultations regarding the environmental effect evaluation process for projects, as this must also be considered.

1.2. Shapes and images

1. View from the air of the station together with the wastewater line;
2. The station and nearby populated villages;(Figure 7)
3. Water wells (Figure 8.);
4. Agricultural crops (Figure 9);
5. Awareness programme in the case of local communities (Figure 10).

Figure 5 Photographs of local communities and fertile agricultural valleys and swamps adjacent to the channel

Figure 6 Agricultural areas in BaniHarith

Figure 7 Images of awareness program for local communities

1.3. Physical and biological test results

Sampling for physical, chemical and biological analyses has been carried out in the period 2013-2014 in the area of the Sanaa wastewater treatment plant. The analyses were done and collected in (Table 3) and (Table 4) The results of the analyses carried out on the samples taken from the citizens' shallow wells (1 and 2) The results of the analyses carried out on samples taken from the state well (3). Results of analyses carried out on vegetable samples (4)

Table 3 Physical and biological test results

Parameter	Unit	Value 1	Value 2	Value 3	Value 4	The WHO Guide
Electrical conductivity at 25^0C	µs/cm	1709	2580	455	132.4	-
Total dissolved solids (ECx 0.65)	mg/l	1111	1677	296	86	1000
The total CaCO3 hardness	mg/l	613	106	46	100	500
Calcium	mg/l	168	286	8	28	200
Magnesium	mg/l	47	148	6	7	
Turbidity after filtration	NTU	10	Zero	1	12	5
Chlorine	mg/l	171	295	52	13	250
COD organic substance	mg/l	20.8x10	38.5x10	3.5x10	24x10	-
Sodium	mg/l	131	113	85	11	200
Potassium	mg/l	3.99	6.28	1.49	6.66	
Nitrate	mg/l	289	652	15	24	50
The total number of Coli organisms	Col/100ml				857,143	0
Coli organisms from feces	Col/100ml				600,000	0

For 2014 the average BOD5 results are presented in Table 4 and Figure 8

Table 4 Average BOD5 results

	Parameters	**Output**	**Input**
January	BOD5	201 mg/l	1071 mg/l
February	BOD5	150 mg/l	1280 mg/l
March	BOD5	169 mg/l	1076 mg/l
April	BOD5	267 mg/l	1201 mg/l
May	BOD5	219 mg/l	1307 mg/l
June	BOD5	249 mg/l	1017 mg/l

Source: Laboratory report, 2014

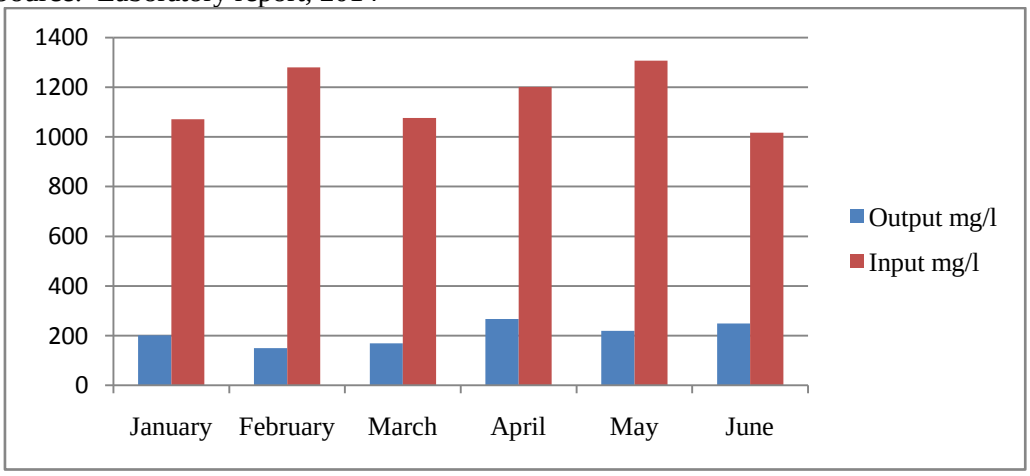

Figure 8 BOD_5 average results

Conclusion

In Yemen there are no legislative norms concerning potable water, nor for irrigation water. Standars 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 microbilogical and chemical saturation, but in some cases these values are excedded.

The majority of contaminations are cauzed 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 acommodatelarger quanititiesto increase capacityaccordingly to keep pace with the region's development.

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

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

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