ENVIRONMENTAL IMPACTS OF DISCHARGING HEAVY WATER IN BASRA PROVINCE

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ABSTRACT

Discharging of heavy water directly to the environment without treatment, due to the failure of the drainage network, showed that the rates of the concentrations of chemical and biological pollutants are relatively high in the waste water of Basra city compared to international and Iraqi standards. The study of the environmental impacts of the heavy water drainage in the city revealed the extent of the problem and the serious damage to the environment and human beings together. It is the main pollutant of the river environment which contribute to the pollution of drinking water, as well as their reflections on other environmental aspects such as the residential environment and the cultural appearance of the place (visual pollution).

INTRODUCTION

Most of the heavy water, in the city of Basrah, resulting from different uses is discharged directly to the environment without treatment, which leads to the pollution of the environment, and creating adverse effects on both the environmental and health aspects, as well as its enormous impacts on the environment and human beings as a real environmental problem with high - visibility effects.

AIM OF THE RESEARCH

The research aims to extrapolate this problem locally by studying the patterns and methods of discharging heavy water in the city of Basra, the third major city of Iraq, and to show the high - visibility environmental effects resulting from its discharge.

HYPOTHESIS OF THE RESEARCH

The problem will be exacerbated and increased with the population growth and the cultural and industrial development.

RESEARCH PROBLEM

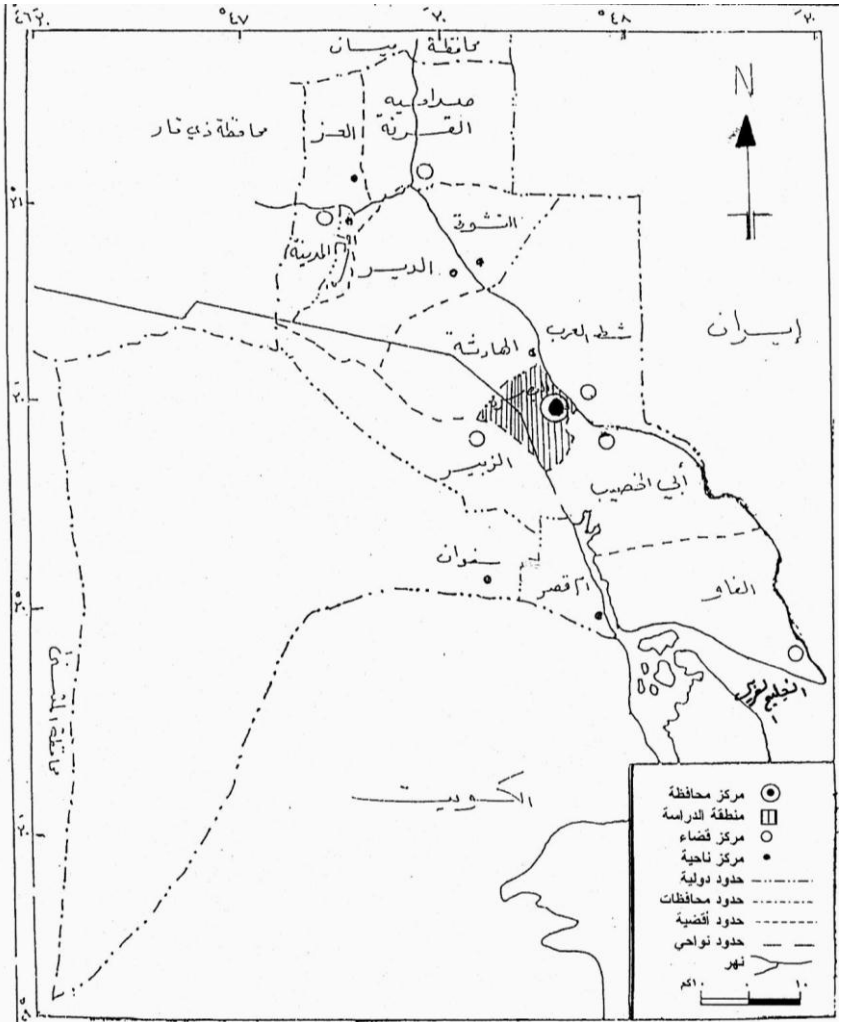
The discharge of heavy water is a global environmental problem that most countries of the world and their main cities suffer from. This problem, with the population growth and the cultural and industrial development, has been exacerbated and intensified.

BOUNDARIES OF THE RESEARCH AREA

The spatial boundaries of the study area extend to the city of Basra within the latitude 33o 30- - 34o 30- north and longitude 51o 47- - 56o 47- East, map No.(1). The borders are from Karma River to the north and Saraji River to the south and Shatt al-Arab River to the east and Basra River to the west. They cover an area of

170 km2, which forms (0.89%) of the total area of Basra Governorate which is 19070 Km2 (Basrah Governorate, Directorate of the Municipality of Basra, 2015; None), while the temporal boundaries extend from 2000 to 2016.

Map (1): The location of study area Basra Province



General Board for Surveying, Administrative map of Basra province (Baghdad, 2004)

Heavy water has great impacts on the environment and man in the city of Basra, where it led to change the characteristics of the Shatt al Arab River water and its lateral branches. It also has adverse effects on the river environment and residential area causing drinking water pollution and the spread of many diseases.

The most significant effects are:

FIRST: POLLUTION OF THE RIVER ENVIRONMENT

Ecosystems have been able to absorb pollutants for scarcity of their concentrations and lack of hard soluble solids, but at present time the water environment has become unable to absorb the pollutants or eliminate them for its intensified concentration and the presence of hard insoluble solids. These concentrations exceed greatly the permissible limits. (Gharabia & Farhan,1987,199) . For example, the increasing of the presence of nutrients such as phosphates and nitrates in water will lead to the growth and reproduction of phytoplankton (AlSaadi, 1986, 41), and this would destroy a lot of the rings of the food chain and then eliminate many species of life in water environment. The Department of Environment Protection and Improvement has identified the phenomenon of pollution of the aquatic environment as: "a change in the physical and chemical properties and

aesthetic qualities that occur in water in a manner that leads to degradation and low quality so that it becomes harmful to the beneficiary or harmful to the surrounding environment".

The river environment of Shatt Al-Arab and the its lateral branches in Basra Province has been exposing to severe pollution because of the influx of heavy water resulting from sanitary sewers , industrial wastes, rain as well as agricultural irrigation water which contain various organic and chemical materials as mentioned before which makes it unsuitable for all uses as it is considered a source of drinking water in many districts of the city and also an important source of watering and draining agricultural lands as well as an important source of navigation and fishing. It also forms natural drainage for the underground water (Al-Saadi, 1995, 186). Pollution of river water environment in Basra appears through the change of its physical, chemical and biological properties. Water in Shatt al Arab and its lateral branches is characterized by the low degree of its transparency and turbidity due to the presence of solid phytoplankton and its grey color (fig.1), and a slimy black bottom of sludge∗. That water is also characterized by an unacceptable smell resulting from algae decomposition besides the organic and solid materials and the dead organisms, (Depart. Of environment protection & development, 2000)

The concentrations of chemical elements in that water rises due to the disposal of different materials and chemical compounds in it, such as detergents that come with sanitary sewage in particular, and other materials resulting from industrial drainage. The results of the chemical analyses of Shatt al-Arab water and its lateral branches indicate that the rates of some elements exceed greatly the permissible limits. The amount of soluble substances in the water reaches (3875.8) mg / L which is more than ten times the permissible limit. The chloride rate is (2165.4) mg / L, while its average should not exceed (400) mg / L, according to international standards. Calcium, magnesium and sulfate are also high in Shatt al-Arab water and its lateral branches which is four times higher than their rates according to international standards as shown in table (1). The heavy water discharged to the river environment in the city of Basra also leads to an increase of the water hardness rate to reach (560.7) mg / L, which exceeds the permissible limit of (400) mg / l (Table 1).

Fig (1): Khandek branch is polluted by discharging materials, notice the pipe buried under the solid waste (garbage) , and residue of oil on the banks of the branch as well as solid wastes. 18/11/2015

∗sludge: is organic materials and microorganisms that are not fully dissolved, source (Al-Hadithi,237,1986)

Table (1): Results of chemical analyses of Shatt al Arab River and its lateral branches mg/L

location	Solvable materials	Chlorides	Calcium	Magnesium	Sulfate	Turbidity	pH value	Salinity ds/m
Shatt al Arab	2480	132	322	488	350	810	8	3815
Maqal branch	2676	770	149	111	——	260	——	——
Jubayla branch	2840	598	144	117	——	261	——	——
Robat branch	4681	7314	421	421	4413	842	——	——
Khandek branch	7275	3607	392	307	2159	699	——	——
Ashar branch	4386	1724	404	242	989	646	——	——
Khora branch	2793	1013	245	162	582	407	——	——
The highest permissible limits	500	200	75	50	200	400	7	——

Source: Ministry of Health, Basra Health Directorate, Dept. of Environment Protection and Development, Pollution Branch, chemical analyses records, 2005. (unpublished data)

The decomposition of dead organisms leads to lower the dissolved oxygen values in that water which is less than (3.4) parts per million in the branches, while its rate in Shatt al-Arab (6.7) part per million, or about twice the rate in those branches (Hussein et al., 1991, 340). It is worth mentioning that aquatic life will be rare if the concentration of dissolved oxygen is less than 5 ppm (Lagler, 1956, 20)

The containment of the heavy water, especially the sanitary sewer, of many kinds of bacteria and organic materials lead to change the biological characteristics of the river environment in the study area. The pollution level rises to (2400000 per 100 ml) at the low tide and (900 per 100 ml) at the high tide, and this exceeds the permissible limits by (1000) times, as shown in Table (2)

Table (2) bacteriological analyses results of Shatt al Arab River and its lateral branches in Basra Province during high ad low tide

Location	Pollution Degree per (100) ml*	
	Low tide	High tide
Shatt al Arab (at Maqal)	11000	2400000
Shatt al Arab (at Bradhiya)	240000	11000
Khora branch	240000	9000
Ashar branch	240000	——
Robat	240000	4300000
Khandek	1400000	15000
Jubayla	240000	460000
Maqal	240000	240000
Low permissible limits	2400	

Source: field study, date of samples examination 25/10/2011

There is a spatial variation in the characteristics mentioned above; as Table (2) shows that some branches in the city are more polluted by heavy water than other branches and even from Shatt al-Arab. The highest concentrations of those elements were recorded in (Robat, Khandek and Ashar) branches. That can be

∗Pollution degree: is the rate of bacteria colonies per (100 ml).

attributed to that many industries are localized on both sides of these branches, such as food industries that discharge heavy water containing yeast, acid and oil liquids, as in the case of dairy industries as well as the salty water resulting from washing milk and juice bottles, besides what is discharged of fats ,dyes and acids from the workshops of boats repair and irrigation pumps, , leading to raise the levels of concentration rates of chemical pollutants compared to other branches and Shatt al-Arab. For example, the amount of soluble substances in Khandek branch is approximately three times the quantity in the river of Maqel and al-Khora. It should be mentioned that the solid waste that is discharged in the branches by some citizens contributes to a large extent to polluting the water as shown in the pictures. (2) , (3), (4).

Fig. 2: Ashar branch pollution by discharging pollutants resulting from domestic uses as well as discharging solid waste (garbage) on its sides. 8/11/2015

Fig (3): Ashar branch pollution one of the main branches of Shatt al Arab River as shown different pollutants from different uses . 8/11/2015

Fig (4): Pollution in Khandek branch, note the solid waste as well as wastewater discharged. 8/11/2015

It is also noticed that there is a relatively spatial variation in the degree of bacteriological contamination, especially during the tide period. This degree decreases in the Maqel, Jubaila and Al-Khorah branches due to continuous cleaning operations in these branches compared with other branches in the city, as well as in the Shatt al-Arab to reach (24000, 460000, 9000, 11000) per 100 ml respectively, Per 100 ml), while it rises in the rest of the branches to (2400000 per 100 ml)- Table (2). It is worth mentioning that these values are equal in all brnches and in the Shatt al-Arab during the period of the low tide. Some of the water variables affect the spatial variation of pollution levels in the river environment in Basra, among these variables:

1. The slow movement of water in some branches, due to the presence of plankton and solids materials, as well as the disposal of solid waste (garbage) by the citizens, and the abundance of sediments and silt, which leads to the failure to reach the water of Shatt al-Arab to these branches equally during the period of the high tide. (Douabl, 1987,167)

2. The poor effect of the tidal phenomena in the branches compared to Shatt al-Arab for the reasons mentioned above.

3. The decrease of water levels in Shatt al-Arab river and the lateral branches generally in recent years.

SECOND: RESIDENTIAL ENVIRONMENT POLLUTION

The residential environment in the city of Basra is contaminated with domestic sanitary sewage, where residents of some residential areas discharge water of domestic uses, especially in some districts that do not have heavy water drainage network and the districts that suffer from constant overflowing, into open spaces or lowlands or to the streets. Some of these wastes take their way to storm sewer networks that end with the branches in the city by digging open or lined channels – fig (5)

The accumulation of stagnant heavy water in front of or near the houses leads to the decomposition of organic materials and the emission of stinking odors as well as the proliferation of different bacteria , rodents and insects. This phenomenon contributes to the pollution of the residential environment, and it has bad effects on both the environmental and aesthetic sides. The tampering of children in those contaminated ponds in some

slums in the city leads them to be injured by various diseases and exposing to drowning in them, as is the case of the lowland in the residential apartments in Al-Muwafaqih Quarter. The accumulation and stagnation of these ponds also affect the aesthetic of the residential environment - fig (6), which reflects an inappropriate appearance of the city from the cultural point of view. It is worth mentioning that the dumping of garbage in these ponds or lowlands makes them worse - fig (7). They become the breeding grounds behind the spread of diseases, insects and rodents, and this phenomenon varies at the level of the place in the city of Basra, as some alleys and branch streets in residential areas are filled with channels and sewers in front of the houses which discharge domestic uses water as the case in Al- Hussein, Al-Jamhuriya, Al-Hadi, Al-Qadisiya, old Basrah, Al-Asma'a, Sana'a Quarters, and it is getting worse in the winter, especially during the rainy season.

Fig (5) :A course for the discharge of domestic uses water in one of the districts of Basra city in the inspection basin of storm sewer ending in Khadek branch. 8/11/2015

Fig. 6: Heavy water catchment resulting from domestic uses as well as the accumulation of solid waste (garbage) in one of the districts of Basra. 8/11/2015

Fig (7): A course to discharge heavy water in Al-Hadi district in front of the shops. 8/11/201

THIRD: DRINKING WATER POLLUTION

Drinking water is exposed to pollution due to the heavy water discharged to Shatt al Arab and its lateral branches, either by water treatment stations located on the sides of the Shatt al Arab River which takes its water from three locations (Jubayla, Robat and Bradhiya) or through distribution networks connected with them which take the water from Bada' project. This water is exposed to pollution through the pipes breaks and neglect of the drinking water network, as well as the encroachment of the citizens on those networks (illegal connections). The river environment in the city of Basra is contaminated with heavy water this is shown by the study of its physical, chemical and biological properties. Despite the continuous treatment processes⁎ performed when it is drawn to the mentioned treatment stations; however these processes do not dispose the water from all the pollutants, especially the chemical and some salts. It is shown in table (3) that there is a large increase in chlorides, magnesium , calcium , suspended sediments , pH and the electricity connectivity exceed what is permissible. The chloride rate, whether in raw water before treatment or drinking water after treatment, exceeds the permissible limits of about three times, and the magnesium and calcium levels are doubled while the suspended sediments levels increase by more than ten times what is permitted. The drinking water is exposed to pollution by the sanitary sewage through the pipes of the distribution network, which suffers from breaks , poor connectivity and damage because it is very old on the one hand and the encroachment and tampering of some citizens(illegal connections) on the other hand.

Table (3): Chemical properties of drinking water in Basra province before & after treatment mg/L

Properties		Chloride	Magnesium	Calcium	pH value	EC	T.D.S
Bradhia station	Before treatment	626	115	184	7.72	5000	3032
	After treatment	616	115	176	7.62	5000	2988
Robat station	Before treatment	135	146	76	8.08	1419	800
	After treatment	135	146	76	7.98	1419	776
Jubayla station	Before treatment	176	50	99	7.87	1624	1004
	After treatment	176	51	95	7.71	1624	1000
Permissible limit		200	50	75	6.5	—	250

Source: Ministry of Interior Affairs, Basra Water Directorate, Lab Dept., results of drinking and raw water of the treatment stations, date of samples March, 2002, official records (unpublished data)

⁎ **Water pulled from the sites mentioned on Shatt al Arab River is treated by adding chlorine as it is a sterile material and Alum as a precipitant.**

The accumulation of silt and the external pressure on those stations (Ujam,1993,25), lead to the leakage of polluted water to the pipes of drinking water either by stagnant ponds resulting from overflowing of the sewage in some districts or through the pipes of sanitary sewage near the pipes of drinking water network , which is also suffer from breaks and damage which makes the polluted water of the sanitary sewage enter the pipes of the drinking water network during the pumping and pulling processes. In addition, the increase in the level of groundwater already contaminated by heavy water through continuous leakage from sewage pipes or sewage channels contributes to the contamination of drinking water as it leaks into these pipes through breaks and connecting joints. This phenomenon spreads in most districts of the city, and the contaminated water from the treatment stations or the distribution network reach all districts which partially depend on it⁎.

The contamination of drinking water with heavy water, in particular sanitary sewage that loaded with many types of bacteria and protozoa as well as viruses through studying their biological characteristics, leads to the spread of many waterborne diseases among people, especially those that affect the digestive system, which water is the most important means to transport their causes such as amoebic, basilic, giardia, typhoid fever, viral hepatitis, and diarrhea in children and others. The results of drinking water analyzes are shown in the table (4).

The total number of bacteria in the drinking water in the study area was (190) cells per 100 ml and the number of coliform bacteria was (94) cells per 100 ml, while the number of E. coli bacteria was (43) cells per 100 ml. which greatly exceeds the permissible limits⁎. This number will increase the prevalence of some of the diseases mentioned in the study area, such as the Amebian, Giardia, and typhoid fever⁎⁎. Table (5), which reached (10.4) per 1,000 persons for amoebic dysentery, (10.9) per 1000 persons for Giardia, and (3.9) per 1000 persons for typhoid fever, which is a high rate compared to global rates which reached (8) injury per 1,000 persons, and (0,08) injury per 1,000 persons, and one per 1,000 persons, respectively for each of the listed diseases (WHO,1998,45)

Table (4): A sample of bacteriological analysis of drinking water in Basra Province

Bacteria kind	No. per 100 ml	Permissible limit per 100 ml⁎⁎⁎
T.C	190	3
Coliform⁎⁎⁎⁎	94	10
E.coli	43	2

Source: Ministry of Health, Basra Health Directorate, Dept. of environment protection and development, bacteriology lab division, biological and chemical pollution unit, official records,2002 (unpublished data)

⁎ **The project of Badaa' was inaugurated in 1998 to supply some of Basra districts with drinking water.**

⁎ **Any water entering the treatment station must not be considered potable if it contains coliform bacteria in any sample of 1000 ml, a maximum of 3 coliform bacteria can be permissible provided that they do not contain fecal coliform bacteria. Further see (WHO, drinking water criteria**

⁎⁎ **Data on all of the above-mentioned diseases were not available, so only those diseases were indicated.**

⁎⁎⁎ **see also (AlAnsari, 1979,159) (drinking water quality criteria)**

⁎⁎⁎⁎ **Coliform croop is an indicator of contamination of drinking water with sanitary sewage, especially fecal waste.**

Table (5): The number of infections of some infectious diseases and their prevalence rates in the city of Basra in 2002

Disease	No. of infections	Prevalence rate*
Dysentery	8540	10.4
Giardia	8616	10.9
Typhoid fever	3242	3.9

Source: Researcher work depending on Basra Health Directorate, Dept. of Planning & Statistics , Statistic Division, official records, 2002 (unpublished data).

The above-mentioned diseases are spread throughout all districts of the city without exception, although there is a variance in their quantitative data; as shown in Table (6) and Maps (1), (2); however the results of Chi square confirm that there are no significant differences in distribution according to their recorded values for the diseases Amebic Dysentery, Giardia and Typhoid (24.79, 43.3, 18.2), respectively, when compared with the table value of 25 at a degree of freedom of 15 and the significance level of 0.05, which confirms the impact of drinking water pollution with sanitary sewage in the spread of those diseases, where all people are exposed to them in the study area by the arrival of their causes to them through the water treatment networks.**

Table (6): Prevalence rate and standard degree for the infectious diseases (one infection per 1000 persons) in Basra province 2002.

Location	Infectious diseases					
	Dysentery		Giardia		Typhoid	
	Prevalence rate	Standard degree	Prevalence rate	Standard degree	Prevalence rate	Standard degree
Ashar	3.3	0.2	9.3	1.9	0.3	– 0.8
Old Basra	1.9	– 0.4	9.3	1.9	0.4	– 0.7
Bradhia	1.1	– 0.8	1.3	– 0.8	0.7	– 0.4
Al-Hussein Q.	5.5	1.3	3.9	0.1	1.5	0.4
Al-Khalije AlArabi	5.9	1.5	2.5	– 0.4	0.9	– 0.2
Qibla	3.1	0.1	3.4	– 0.1	0.9	– 0.2
Al-Amin Al-Dakhili	0.5	1.0	5.1	0.5	0.7	– 0.4
Al-Nakheel (Al-Fayha)	1.7	– 0.5	1.2	– 0.8	0.4	– 0.7
Al-Jazaire	4.5	0.8	9.9	2.1	1.6	0.5
Maqel	1.2	– 0.8	0.6	– 1.0	0.2	– 0.9
Al-Hadi	0.8	– 1	1.2	– 0.8	0.2	– 0.9
Al-Andalus	0.2	– 1.2	0.2	– 1.2	0.4	– 0.7
Al-Asmaaee	0.3	– 1.1	1.1	– 0.9	7.1	0.2
Al-Risala	7.1	2.0	5.0	– 0.4	4.3	3.2
Al-Jamhuriya	1.6	– 0.6	4.6	0.3	1.2	0.1
Mwafaqiya	2.3	– 0.2	1.2	– 0.8	2.9	1.8
Total	45.5	0.3	59.9	– 0.4	23.7	2.1

Source: researcher work depending on Basra Health Directorate, Dept. of Planning & Statistics , Statistic Division, official records,2002 (unpublished data)

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* **Prevalence rate is counted according to the equation:** $\frac{infections\ rate}{population\ No.} \times 1000$

** $X^2 = (observed\ value - expected\ value)^2 / expected\ value$ **Chi square is compared to table value after calculating degree of freedom at o.o5 level of significance and degree of freedom n – 1 (Alsofi,1985,9)**

CONCLUSIONS AND RECOMMENDATIONS

It is found by the research that the problem of heavy water discharge is a global problem that most of the countries of the world suffer from and it has extended roots in history. This problem has grown and worsened and its serious effects on the environment have increased with the population growth and the industrial development. Heavy water has several sources, the most important of which are sanitary sewage from domestic uses, industrial discharge , agricultural uses, rainwater, illegal uses and others.

Heavy water contains many chemical and biological pollutants. These pollutants vary depending on the source of the heavy water, whether domestic, industrial or otherwise. They have bad effects if discharged to the environment without treatment, causing pollution of aquatic environments. There are many evidences for that where most of rivers in the world suffer from pollution due to discharging heavy water in them, and pollution has killed many living organisms living in these rivers, as well as its effects on humans through its various uses of water. It has become obvious that the heavy water in the city of Basra has many sources as other cities in every place in the world, the most prominent sources are sanitary and industrial sewage , agricultural uses and rainwater. These are discharged in different ways, most of which are environmentally and healthily unacceptable, as is the case for discharging domestic wastewater.

It is found that most of the heavy water is discharged directly to the environment without treatment due to the failure of the sewage network. It is also found that the concentrations of chemical and biological rates are relatively high in the wastewater in the study area compared to the international and Iraqi standards. The study of the environmental effects of heavy water discharge in the city revealed the size of the problem and the damages that caused for both the environment and the human beings . It is a major contaminant of the river environment, where it contributes to the pollution of drinking water as well as its effects on other aspects of the environment such as the residential environment and the cultural appearance of the place.

SOME OF THE RESULTS ARE

- **The geographical characteristics of the study area include natural and human factors, which helps to the emergence of the problem of heavy water discharge.**
- **Most of the sanitary sewer water resulted from domestic and service uses is discharged to the environment without treatment, due to the low efficiency of the sewage network and its failure.**
- **The various industries spread in the study area are discharging their heavy water to the environment due to the lack of treatment units in some of them or the failure of treatment units in others, as is the case in the power plant in Najibiya.**
- **The illegal connections of sanitary sewers with storm sewer (Rainwater drainage) network in many districts of the city, where storm water pumping stations discharge their water into the branches that extend into the center of Basra province.**
- **A number of factors have contributed to the reduction of the efficiency of the heavy water discharge network in Basrah province, which came from the political conditions that prevailed in the country prior to 2003, as well as geographical factors related to the topography of the place, the nature of rainfall, the characteristics of the soil and the level of groundwater, which adversely affect to extend the network and increase the cost of its construction.**
- **The river environment in Basra province is the only location for the disposal of heavy water which leads to its pollution and changes its natural, chemical and biological properties. The values of dissolved oxygen have**

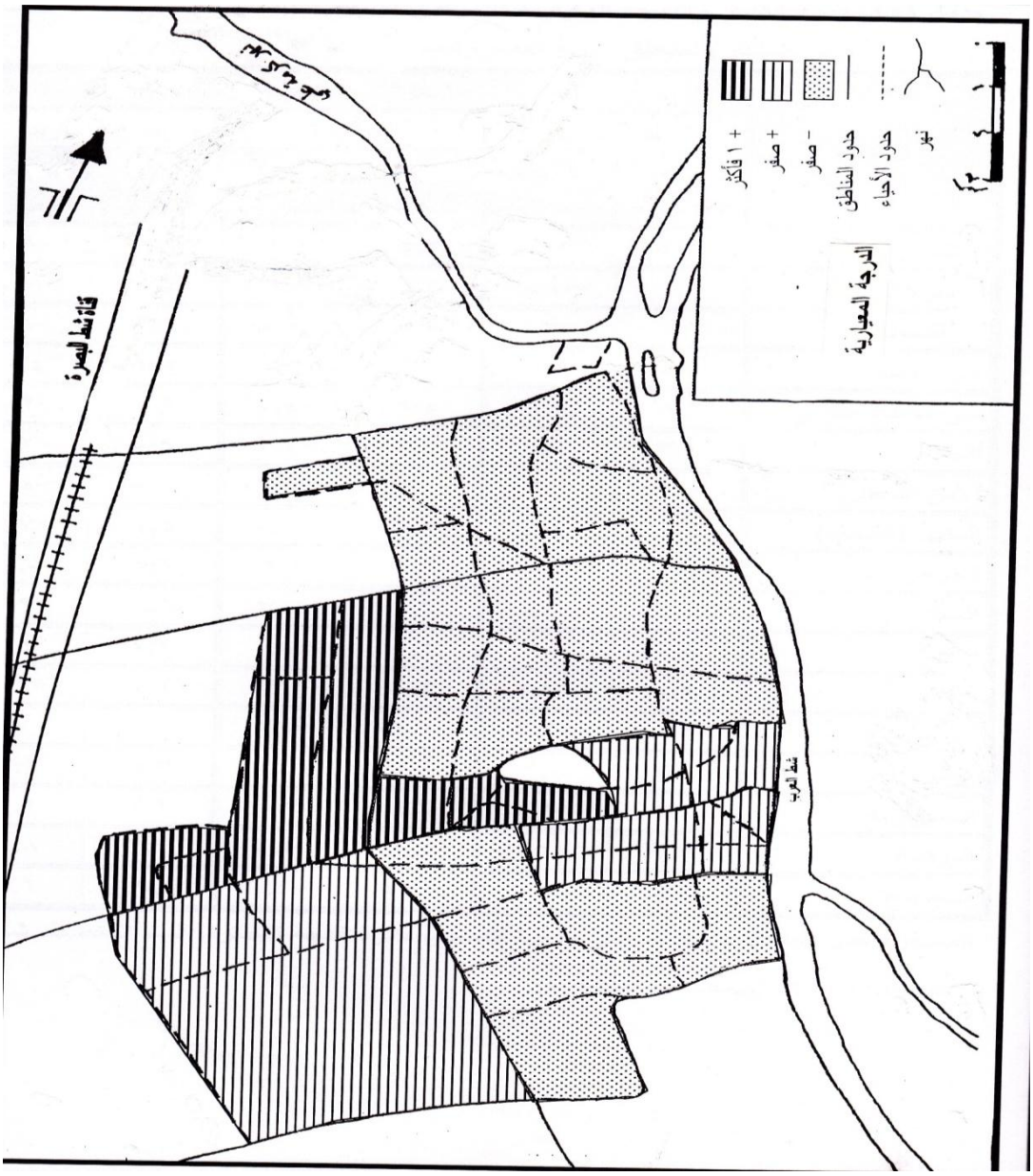
decreased, leading to the scarcity of most life forms, especially in the branches extended in the city. These branches have become sewers that transport heavy water to Shatt al-Arab River, and also lead to the rise of some salts in their water.

- **There is a variation in the level of pollution caused by the heavy water discharged to the river environment in the city where the concentrations of some pollutants in the branches of Ashar, Khandek, and Robat are higher compared to other branches and Shatt al-Arab because of the industrial and commercial activity on the sides of those branches, leading to increasing the heavy water discharges.**
- **The lack of self-purification efficiency that can be caused by the high and low tides in the branches extended in the city because of the sediments and low levels of water in general.**
- **The impact of the residential environment by the problem of heavy water discharge and the suffering of some districts from the continuous overflowing and the spread of stagnant ponds near the residential houses, which reflects an inappropriate appearance in terms of environmental and aesthetic aspects , as well as health aspect, where the causes of infectious diseases are spread, and this phenomenon varies at the level of the place as it appears more prominent in some districts of Basra province than others (visual pollution).**
- **Contamination of drinking water as a result of heavy water leakage through water treatment plants or distribution network that reaches all districts of the city without exception.**
- **Contamination of drinking water has led to the spread of some infectious diseases among the people, especially those diseases in which water is a means of transporting their causes, which have emerged with high prevalence rates that exceed their global prevalence.**
- **These diseases did not take a specific pattern in the study area, although their quantitative data varied at the local level due to the exposure of the whole people to their causes by the water treatment network or tanks of water.**

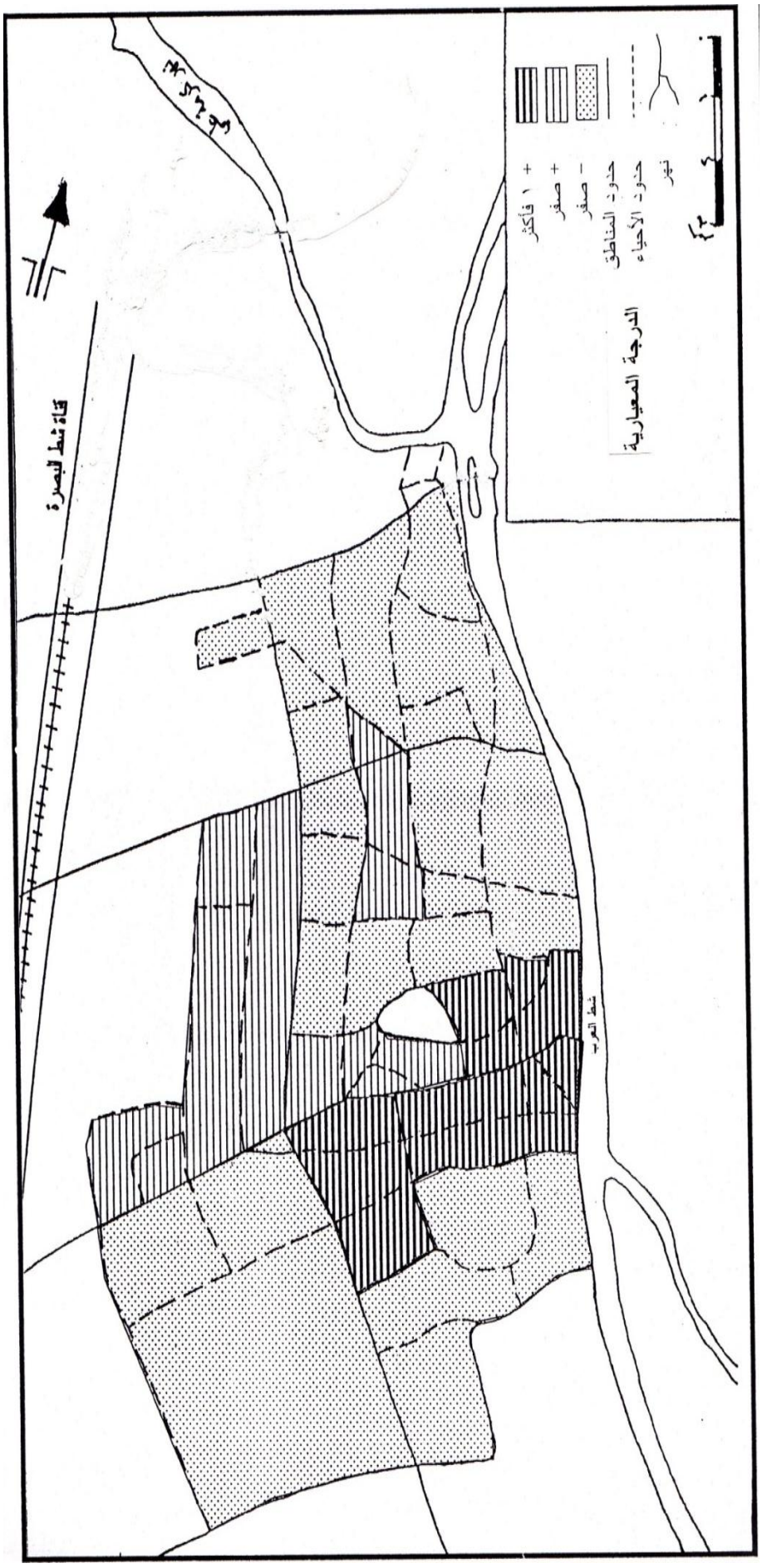
RECOMMENDATIONS

- **Provide adequate maintenance of equipment and networks.**
- **Make holes to receive rain water under the level of the street when repaving the streets.**
- **Raise the level of efficiency of workers and technicians in the Directorate of sewage.**
- **Divert the heavy water of industries , services and health institutions into special tanks and connecting them to the main sewer network after completion.**
- **Treatment of heavy water resulting from the main industries, food industries and industries that produce liquid and solid waste before discharging to the branches extended in the city.**
- **Dredge the branches from time to time and cleaning them from solid waste (garbage) and close the pipes and openings that end with the branches containing pollutants.**
- **Establish gateways at the beginning of each branch that allow water flow to the end of the branch at the high tide and close at the low tide to keep the water in the branch as long as possible and reach the end of the branch and reopen it in low tide period for the purpose of cleaning the watercourse in the branches.**
- **Completion of the implementation of the remaining stages of the network to include all residential districts in the city of Basra and raise the efficiency of the capacity of the purification project in Hamdan.**
- **Tighten the control over the houses and service, community and industrial institutions and prevent them from trying to extend pipes of discharging heavy water to the branches.**

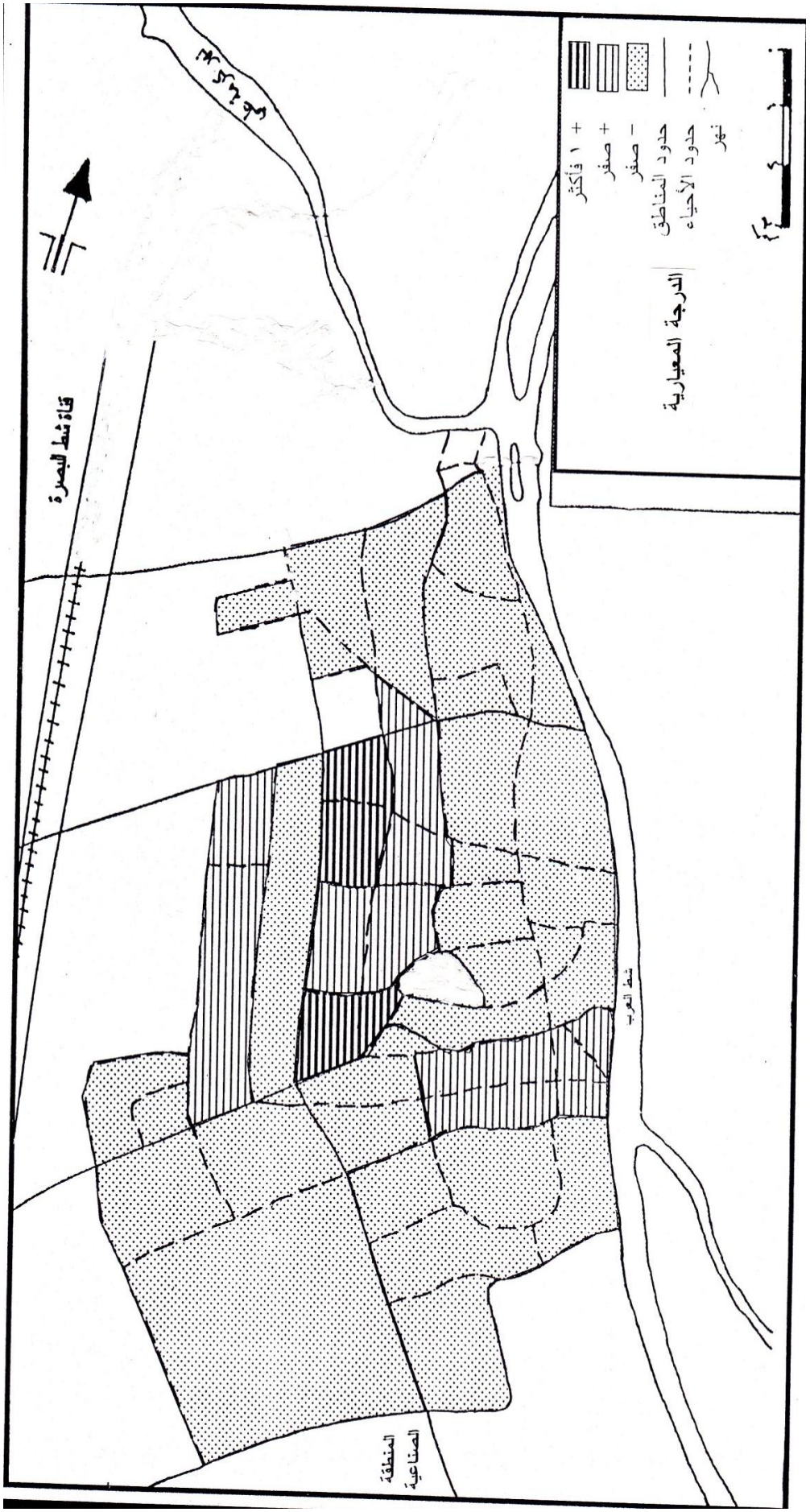
- **Take advantage of heavy water after treatment and purification in the watering of public parks after reforestation.**
- **Remove the stagnant heavy water in the residential districts of the city, where there is no sanitation services, by tank trucks from time to time.**
- **Facilitate the procedures concerning sewer services throughout the city.**
- **Establishment of a technical inspection section subjects to the Department of Protection and Improvement of the Environment to handle the problem of heavy water leakage associated with municipal Services and Water and Sewerage Services.**
- **Coordination between water and sewerage agencies and other agencies specialize in the delivery of sewage services to the population.**
- **Tighten the control over the ice factories and close the factory in a timely manner in the case of pulling water from the nearby branches for the purpose of cooling or washing the special molds due to leakage of the contaminated water of the branches to those molds and mix with the water, causing the spread of infectious diseases, especially during the summer period, where demand for ice increased.**



Map (2): Spatial distribution of prevalence rates of Dysentery in the city of Basra for the year 2000



Map (3): Spatial distribution of prevalence rates of Giardia in the city of Basra for the year 2000



Map (4): Spatial distribution of prevalence rates of Typhoid in the city of Basra for the year 2000

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الآثار البيئية لتصريف المياه الثقيلة في محافظة البصرة

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الملخص :

أظهر تفريغ المياه الثقيلة مباشرة إلى البيئة بدون معالجة، بسبب فشل شبكة الصرف الصحي، إرتفاع معدلات تركيز الملوثات الكيميائية والبيولوجية مرتفعة نسبياً في مياه الصرف الصحي بمدينة البصرة مقارنة بالمعايير الدولية والعراقية. كشفت دراسة التأثيرات البيئية لتصريف المياه الثقيلة في المدينة على مدى المشكلة والأضرار الجسيمة التي لحقت بالبيئة والبشر معاً. كما إنها تعتبر الملوث الرئيسي للبيئة النهرية التي تسهم في تلوث مياه الشرب، فضلا عن انعكاساتها على الجوانب البيئية الأخرى مثل البيئة السكنية والمظهر الثقافي للمكان (التلوث البصري).