



## Geographical analysis for the chemical characteristics of water and their influences on human health Al Kufa City

Muthanna F Ali <sup>1\*</sup>, Aqeel Hasan Yasir Alnajim <sup>2</sup>, Dheyaa Baheej AL-bairmani <sup>3</sup>, Alyaa Hussein Salman <sup>4</sup>

<sup>1</sup> University of Kufa, College of Arts, IRAQ

<sup>2</sup> University of Kufa, College of Medicine, IRAQ

<sup>3</sup> University of Babylon, College of Education for Human Sciences, IRAQ

<sup>4</sup> University of Kufa, College of Education for Girls, IRAQ

\*Corresponding author: [muthana.alwaeli@uokufa.edu.iq](mailto:muthana.alwaeli@uokufa.edu.iq)

### Abstract

The chemical characteristics of water differ according to its place and time in the area of study. Its influences also differ according to the different concentration of chemicals in the water. This paper searches the geographical analysis of the chemical characteristics for some samples of water of the Euphrates River at Kufa city; those samples of water were compared with samples from the water of the drinking tap water and the packed water at AL Kufa City. Also eight samples of mineral water were taken from the markets there in Kufa. After analyzing all the samples at the labs, the research presented the influence of the chemicals in these samples of water on the health of people and the diseases that people might get because of the polluted water. The statistics of the study state a relation between the concentration of chemicals in the water and the diseases among the people in the area of the study (0.6) that is any increase of the concentration of the chemicals in the water leads to the increase of diseases among people there. The study involves the following topics:

A- The theoretical background of the research and the basic elements of the research such as the problem, hypothesis, aims of the study and its limits.

B- Analyzing and deciding the chemical characteristics of water at the area of the study.

C- Identifying the health influences of the water in Al Kufa City.

**Keywords:** water, influences, Kufa, health

Ali MF, Alnajim AHY, AL-bairmani DB, Salman AH (2020) Geographical analysis for the chemical characteristics of water and their influences on human health Al Kufa City. Eurasia J Biosci 14: 4421-4427.

© 2020 Ali et al.

This is an open-access article distributed under the terms of the Creative Commons Attribution License.

### INTRODUCTION

Water is the basis of life of all living creatures, water is used for several different purposes in different fields such as at home, industrial and agricultural purposes, there is no life without water. The packed water industry has flourished very much in Iraq and its industry is (58.5%) of the formal registered food industry, this increase is due to high demand on the packed water. This high demand increases because of the quality of the drinking water as (92) out of (100) people consume packed water as a main source of drinking water (Baroni et al., 2017).

Polluted water and changing its chemical characteristics is regarded one of the main environmental problems because it is a source of several diseases. Lead is considered the most dangerous chemical pollutant in the water but other chemical such as iron and copper are not so serious unless people get great exposure to those chemicals. Lead is considered so dangerous because it exists in air, water and food that is because of the fast growth of human population and their

different sides of expansion as agricultural, industrial and civilian (Tchounwou et al., 2012). Minerals and chemicals do exist naturally in the fresh water but with different concentrations. The concentration of minerals and chemicals depends on several factors such as erosion producing and using minerals in industry, using chemical fertilizers in agriculture, chemical waste, house waste, transportation pollutants and what is carried by rain (Jaishankar et al. 2014, Fazal-ur-Rehman., 2019 and Fazal-ur-Rehman., 2019).

### MATERIALS AND METHODS

#### SECTION ONE- THEORETICAL FRAMEWORK

##### The Problem

- What are the chemical characteristics of water in Al Kufa City?

Received: February 2020

Accepted: April 2020

Printed: October 2020

- b) What is the difference between the amount of the chemicals in the processed water and the unprocessed water?
- c) What is the health influence of the increase of chemicals in water?

### Hypotheses

a) The quantity characteristics of water in the area of study differ in place and time according to several factors.

b) The quantity characteristics of water differ at the area of study among the water of the river, tap water and the mineral water.

c) The people at the area of study get infected by some diseases due to the fact that the chemical characteristics of water are above the safe levels.

### The Aim of the Study

The research aims to discover the difference of the levels of the chemical characteristics in the water at the area of the study and comparing these levels with global standard levels all over the world. The research also aims to identify the health influences of these chemicals in the water at the area of the study.

### The Study Limits

Kufa City is a part of the province of Najaf that is located in the middle part of Iraq in the middle Euphrates region. Kufa is located in the north east of AL Najaf. Its borders are contiguous with AL Zarqa Village to the north, Al Abassiya and Hurraya villages at the east borders, Al Barakia area at the south and the city center of the Al Najaf city at the west as in map (1). The geographical astronomical location of Al Najaf is located between the longitudinal lines ( $44^{\circ}26-44^{\circ}21$ ) at the east and between the latitudinal circles ( $32^{\circ}5-32^{\circ}0$ ) at the north.

## Section Two: The Chemical Characteristics of Water at the Area of Study

### Preface

The United States Environmental Protection Agency (US EPA) defined water pollution as the existence of some chemical materials that prevent or hinder the natural process and cause health and environmental unwanted problems. Obviously any material that causes pollution called pollutants (Habre et al. 2014; Rumana et al. 2014.). Drinking water is known as the water that is safe for the human use such as drinking, cooking and washing according to Iraqi Quality Standards, whereas the drinking packed water is that processed drinking water, which is safe for human use. The meaning of packed water is that processed water is packed in bottles or cans according to American Quality Standards without any additives except safe anti- micro –biological and ready to be used by humans. (Dorota, 2015).

### 1- The Standard Ways to Process Packed Drinking Water



Fig. 1. The basic map of Al Kufa City 2009. (Ministry of Municipality, 2009)

The source of water at the area of study is the superficial water as Euphrates River or the water distribution stations that need high standard procedures to produce water according to the global quality regulations. This procedure starts by filtering the water after collecting it from the source and then keeping the filtered water in special tanks with different capacities. Those tanks are connected to a tube in which, the water goes through several rigorous filters with special standards and functions, those filters remove the chemical and microbial pollutants (Zolnikov, 2013), those filters are as follows:

**a- Sand Filter:** this filter is used to the materials that influence the next phase of purification and that are responsible for the degree of mud and the microbes load.

**b- Active Carbon Filter:** this filter is used to remove the organic pollutants and the taste, color and smell problems; it is also used to remove the chloride that used in the process.

**c- Steel Filter and Ceramic Filter:** these filters are used to remove the very tiny particle.

**d- Sanitizing by Ozone:** O<sub>3</sub> or Ozone is the strongest active sanitizer against a large amount of bacteria and it is faster than the chloride. This process happens through oxide interaction when the root of the hydroxyl fragments the Ozone in the water, this process leads to deactivate the enzyme activities and attacking the amino oxide series that compose them. The Ozone also solves the problem of color and taste in the water by destroying the basic compounds which are responsible for the stinky smell in the water that cannot be removed by processing procedure. (Jawad, 2009: P. 20).

**e- Ultra Violet ray Sanitizing:** This process is an active way to treat the water by discouraging the micro pollutants such as bacteria by destroying the genetic material of the microbe which leads the microbe to lose its ability to reproduction and this sanitizing process also removes the stinky smell in the water.

**Table 1.** The results of lab tests of water at Al Kufa City according to the standards of the WHO. (Lab Analysis results, 2019, & Website of the WHO, 2019)

| MEAN | Al Kufa River SK | Tap water A | the Median M | Al Kafeel K | Al Safa S | Al Fuad P | AL Furqan F | Al Daffiq D | Afyat I | Mazaya M | who Standards | Components/ mg/l |    |
|------|------------------|-------------|--------------|-------------|-----------|-----------|-------------|-------------|---------|----------|---------------|------------------|----|
| 12.3 | 36               | 0.48        | 0.37         | 0.33        | 0.37      | 0.36      | 0.39        | 0.39        | 0.42    | 0.33     | 0.02          | Iron             | fe |
| 18.5 | 55               | 0.31        | 0.25         | 0.26        | 0.22      | 0.22      | 0.22        | 0.22        | 0.26    | 0.26     | 0             | Lead             | pb |
| 12.2 | 29               | 7.00        | 0.74         | 0.49        | 0.53      | 0.30      | 0.71        | 1.02        | 0.97    | 1.14     | 0.1           | Zinc             | zn |
| 3.7  | 11               | 0.032       | 0.03         | 0.027       | 0.027     | 0.027     | 0.032       | 0.032       | 0.027   | 0.027    | 0.01          | Copper           | cu |
| 78.2 | 128              | 102         | 4.74         | 5.5         | 5.8       | 4.8       | 5.0         | 2.9         | 4.6     | 4.6      | 75            | Calcium          | Ca |
| 65.1 | 95               | 88          | 12.24        | 18.4        | 19.3      | 6.1       | 3.6         | 6.0         | 19.4    | 12.9     | 20            | Sodium           | Na |
| 71.8 | 139              | 75          | 1.4          | 1.7         | 2.0       | 1.2       | 1.2         | 0.9         | 1.3     | 1.5      | 50            | Magnesium        | Mg |
| 61.6 | 121              | 63          | 0.7          | 1.0         | 1.1       | 0.3       | 0.7         | 0.4         | 0.6     | 0.7      | 10            | Potassium        | k  |

## RESULTS AND DISCUSSION

### The Standard Quality Features of Water at Al Kufa City

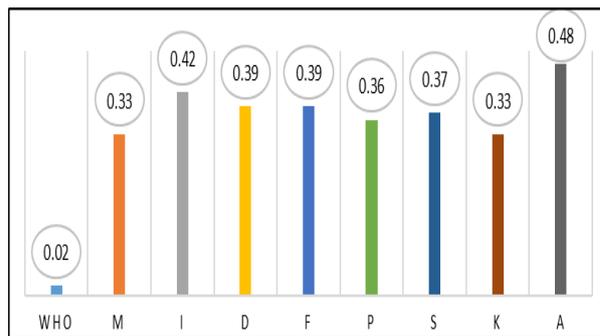
The international organizations and committees have stated special standards to assure the quality of water that include the quality of the source of water and other geographical, social and economic circumstances. Those quality standards must be applicable and assure the protection of public health (Rahmanian et al. 2015). The examination also includes the concentration of (iron, lead, copper, zinc, Calcium, Sodium, potassium, and magnesium). The quality of water at the area of study can be tested according to the standards prescribed by the World Health Organization to determine the quality of water. **Table 1** shows the difference of concentration of chemical at the types of water compared to the standards of the WHO.

#### Iron (fe)

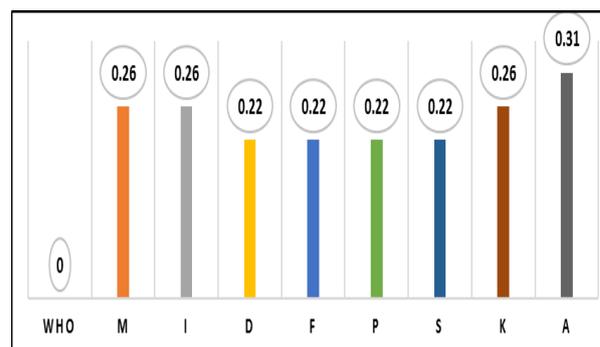
Iron is regarded as the basic item in the human life because it carries the oxygen in the blood and it consists as a main item in producing enzymes. Iron do exist in the fresh water as a result of dissolving mineral in the water rocks, it also can be there in the water because of the rust inside the tubes that transports it. Consuming a lot of iron in water leads to toxic consequences in the human body that cause health problems. From the table above, it can be found that the (fe) concentration in house water is (mg/l 0.48) while the (fe) concentration in the unprocessed water is (mg/l 36) and this percentage is very high and it doubled several times compared to the percentage of Iron the is determined by the WHO. The same problem is in the mineral processed water as the iron on the collected samples of mineral water when they were compared with the standards of iron concentration according to the WHO (Siwila et al, 2017), so it can be said that this water is not safe to the human consumption. (**Fig. 2**).

#### Lead (pb)

It is a heavy metal and high toxic, it exists in the mineral precipitation of rocks and it enters to the environment form natural resources as polluted earth and dust or the industrial activities that use lead in their industry. Lead gets into the water due to the friction of the water utilities, connectors, plumbing systems



**Fig. 2.** Iron concentration mg/l in the drinking water at the area o study compared with the standards of the WHO (Data at **Table 1**)

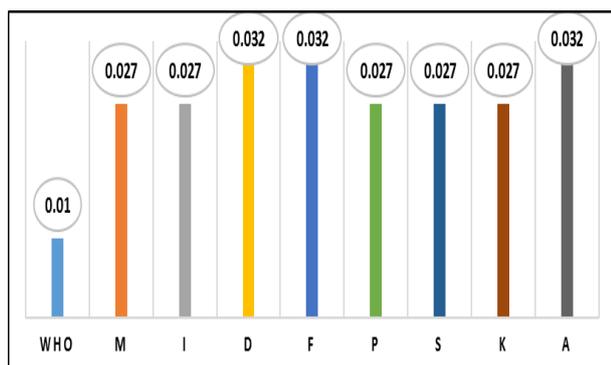


**Fig. 3.** Lead concentration mg/l in the water at the area of study compared with the standards of the WHO (Data at **Table 1**)

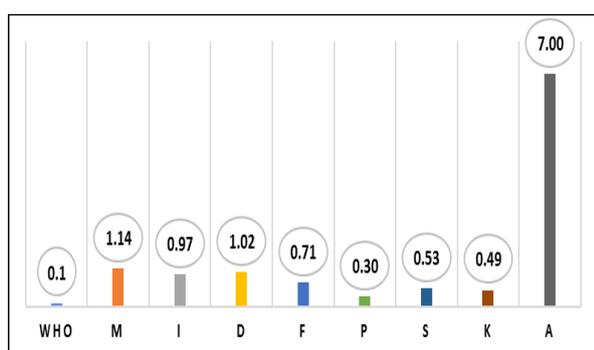
distribution networks, because of accumulation and the concentration of toxic, this can cause health problems such as discouraging the biological production of hemoglobin, brain damage and problems in growth (Gordeuk et al.1992), evolution and cognition. The results of lab tests prove that the drinking tap water and the mineral water in all the collected samples do contain a high percentage of lead as in **Fig. 3** so these kinds of water are not compatible with the standards of the WHO and they are not suitable for the human consumption. The concentration of lead in the water of Al Kufa river reaches (mg/l 55), (mg/l 0.26) in the tap water and (mg/l 0.26) in the mineral water.

#### Copper (cu)

The human body involves several complicated activities to maintain the stable stream of copper



**Fig. 4.** Copper concentration mg/l in the water at the area of study compared with the WHO (Data at Table 1)

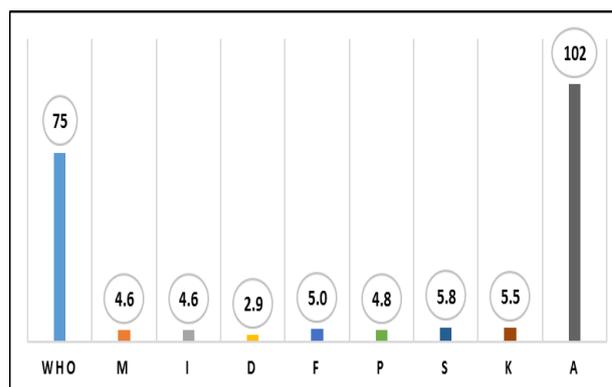


**Fig. 5.** Copper concentration mg/l in the water at the area of study compared with the WHO standards

according to what is available and then the body gets rid of the redundant copper in the body. The redundancy or lack of copper in the body has an influence on the health of the human such as the influence on the liver, bones, central nervous system, system motivate the consumption of the extra copper in the body which leads to indirect poisoning by the interaction between copper and other nutritional elements. On the other hand the lack of copper in the body has an influence on the health such as the dysfunction of the spinal cord, osteoporosis, bones disjunction, joints inflammation, heart and blood vessels diseases (Qu et al. 2018). The WHO determined the right permitted amount of copper (mg/l 0.01) and this percentage goes higher, this will influence on the health of humans. In the collected samples according to **Fig. 4** it can be found that the copper percentage increases to reach (mg/l 0.032) in the tap water and this percentage is high according to the standards of the WHO (WHO,2003), also the percentages are high and different in the collected samples and this explains that water has a high percentage of copper and this makes water unsafe for the human consumption.

#### Zinc (Zn)

Zinc is regarded very essential for the work of many proteins in the body which include mineral enzymes that work in many metabolic functions. Zinc also works in many interactions that produce or disintegrate the carbohydrates, proteins and nuclear acids. In addition to



**Fig. 6.** Calcium concentration (mg/l) in the water at the area of the study compared with the WHO standards

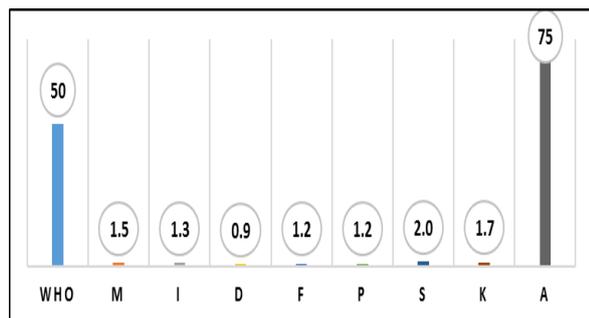
that zinc supports the immunity system and plays a great role in the growth and evolution, the high doses of zinc between (50 – 450 mg/l). (Frost et al. 1977) may cause health problems as vomiting, diarrhea, headache and fatigue. Zinc is regarded as one of the mineral that exist in water and the WHO determined the permitted percentage which is (mg/l 0.10) and if this percentage increases, this will influence the health of humans, in the collected samples of water at the area of study, high percentage of copper has been found which reaches (mg/l 7.00) and this percentage is high compared with the WHO standards. These high different percentages of copper have been found in the water at the area of study and cause health problems there. Look at **Fig. 5**.

#### Calcium (ca)

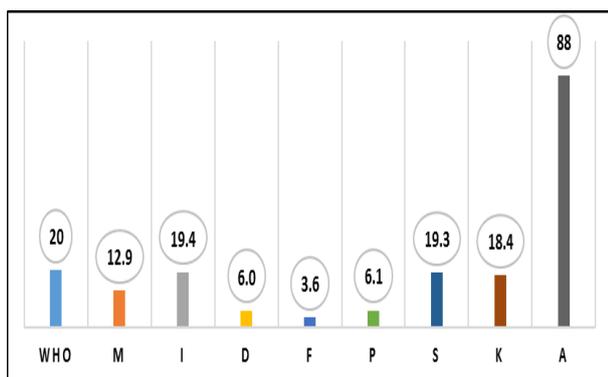
Calcium is regarded as one of the basic ions with positive charge (Cations) that exist in the water, and its lack or increase leads problem in bones, joints and teeth in the human body. The increase of Calcium causes to compose rocks in the kidney and the urinary system. (Ratkalkar and Kleinman, 2011). Calcium ion has a great importance in the water because freshness and quality of water depends on it and calcium is considered as one of the important chemicals for the human body as it is necessary for the genetic growth, pregnancy and lactation. According to **Fig. 6** the drinking water at the area of study is not compatible with the WHO standards as the calcium percentage is very high (102 mg/l) but when the mineral water samples have been analyzed it has been found that calcium is one of the components of mineral water according to the international standards in all samples.

#### Magnesium (mg)

Next to calcium comes magnesium as one of the most basic positive ions that exist in the water. Dissolved calcareous rocks in the water are regarded the main source of magnesium. Magnesium is one of the basic items which are essential for plants to grow and it also plays a great role in enzymatic interactions and producing protein and nuclear acids (Soetan et al. 2010). The increase of magnesium to (50 mg/l) is toxic



**Fig. 7.** Magnesium concentration (mg/l) in the water at the area of the study compared with the WHO standards



**Fig. 8.** Sodium concentration (mg/l) in the water at the area of the study compared with the WHO standards

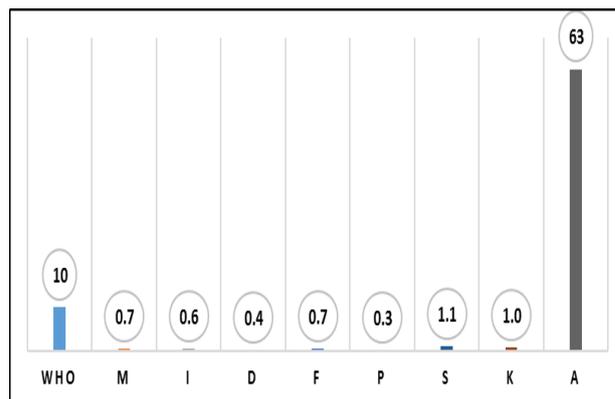
so from **Table 1** it has been found that the concentration of Magnesium in the drinking water (75 mg/l) and it much more than the percentage of Magnesium according to the WHO standards but this high percentage decreases a lot in the mineral water and that mineral water is safe and compatible with the WHO standards in spite of the different percentages in the collected samples of the mineral water.

#### **Sodium (Na)**

Sodium exists with high percentage in the brine natural water and bilge after processing these kinds of water with sodium chloride (Ewaid; et.al 2019; Soetan et al. 2010). The increase of Sodium leads to functional problems of the heart. Its percentage in the drinking water is (88 mg/l) which is incompatible with the standards, according to **Fig. 8** in the percentage of sodium in the tap water increases due to the heavy water and the industrial sewage which pour into Al Kufa River whereas the percentage in the mineral water decreases to reach the permitted amount according to the international standards.

#### **Potassium (k)**

This component has a great role in the function of endocrine glands and its lack in the body causes some health problems. The concentration of potassium in the tap water has reached (63 mg/l) and it is compatible with the WHO standards whereas the collected samples of water which were analyzed in the labs referred to the



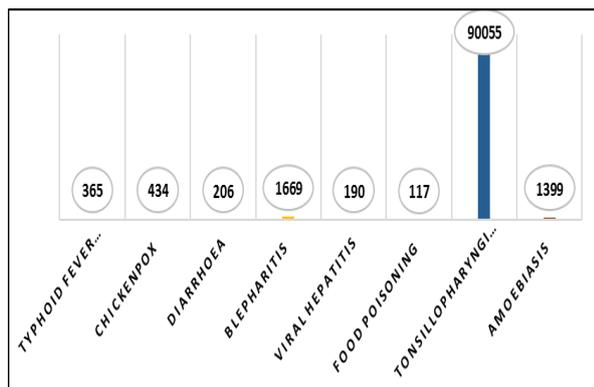
**Fig. 9.** Potassium concentration (mg/l) in the water at the area of the study compared with the WHO standards

fact that the Potassium percentages in these samples are compatible to the WHO standards.

### **3- The Environmental Influence of the Characteristics of Water at the Area of Study**

The area of study has a lot of water outlets (23 outlets) and the results of lab analysis have proved that there is polluted water because of the high percentage of chemical components and ions because of deposition chemical and this influence the human health. The pollutants are very much on the right side of Al Kufa River that include (trocar water, sewage water which are not processed completely due to some violations) all these pollutants make water unsafe for human use especially in winter. Changing the chemical characteristics of water that is consumed by humans in their food, drinking is regarded a main cause of several health problems and diseases such as typhoid fever, Blepharitis, diarrhea, chickenpox, Blepharitis, Tonsillopharyngitis with a number of cases as (90055, 1669, 206, 434, 365) as shown in **Fig. 10**. Those diseases are very dangerous at the area of study and they appear a lot at the area of study because of muddy dispositions at the purification stations and no maintenance for those stations for a long time. In addition to that, the water pipes are so old and have a lot of cracks and the lack of maintenance and no enough chloride used there, as water comes as a result of a purification process by using carbonic calcium, the residues of carbonic calcium stay in the water and may sick to the filters and the distribution pipes that make a block in the filters and pipes and this will lead to reduce its function. (Salman, 2009).

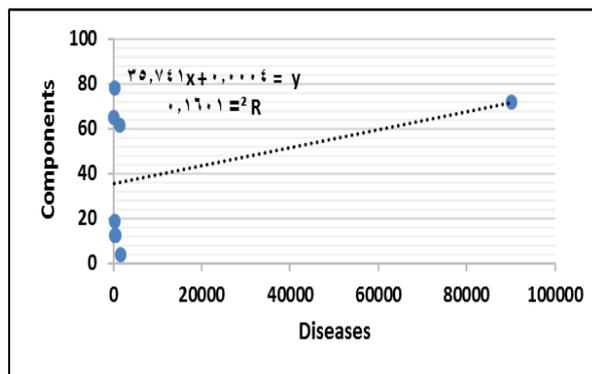
The increase of cases infected at the area of study due to the polluted water comes as a result some activities of inhabitants such as the excessive use of agricultural fertilizers that cause pollution to water sources either directly by pouring these fertilizers into the river or in directly by the a agriculture trocar. According to the research, the Kufa River comes in the center of AL Kufa city which is a tourist city for the people there. The resources also refer that the natural



**Fig. 10.** Cases of infection of several diseases at the area of study in 2019. (Ministry of Health, 2019)

characteristics have a clear influence on the quality of water and the percentage of pollution, the recent components of soil which is less resistant to erosion due to the fast stream of water leads to plough a lot of soil components and as a result of this, the planktons have increased that leads to increase the chemicals because of dissolving the rocks and all this make the river nonacid. In addition to that the less slope of the ground make the inhabitants abuse the areas on the sides of the river for agriculture and living and this makes the soil less fertile and push the farmers to use excessive amounts of chemical fertilizers. That much amount of fertilizers increases the percentage of pollution and the resultant diseases. Furthermore the area has a dry climate with high temperature which makes the people consume a lot of water and this consumption leads to more polluted sewage water into the river without any processing, that pollution makes the people infected with many diseases. Another problem is that the natural plants hinder the river flow and accumulate the pollutants around them and then absorb a lot of water, all these changes the quality of water and its natural components (Al.janabi and Hassan 2010).

#### 4- Statistical Relation of the Chemicals Concentration and Diseases



**Fig. 11.** Direction and Slope of the Influence of the Water Chemical Characteristics on the Level of Diseases

The value of the coefficient ( $r$ ) of the relation between the chemical components in the study and the diseases at the area of study is (0.6). It is a medium positive relation which means that any increase in the chemicals in the water increases diseases with slope coefficient (35.74) as in **Fig. 11**.

#### CONCLUSION

1- The water at the area of study have been polluted by many pollutants which increases the concentration of chemicals in it. One of the pollutants is that drinking water utilities in the living areas is very old and these utilities add some residues to the water.

2- These a clear difference between the percentage of chemicals in the water at the area of study and the WHO standards and the increase of these chemicals cause an increase in the diseases at the area of study, this increase has been proved by the statistical relations.

3- The superficial natural water at the area of study is not safe for drinking because of its chemical characteristics which are out of the WHO standards. This problem of polluted water is very critical and it should be treated seriously as fast as possible in all its levels. The statistical results show that there is a positive relation between the concentration of the chemicals and the increase of diseases at the area of study.

#### REFERENCES

- Aljanabi T, Hassan T (2010) 'Geographical Analysis of the Pollution of the Superficial Water and its Influence on the Spread of Diseases" in Al Kufa City. M.A. Thesis, College of Education for Girls: p.201. University of Kufa-Iraq.
- Azrina A, Khoo H E, Idris M A, Amin I, and Razman M R (2011) Major inorganic elements in tap water samples in Peninsular Malaysia," Malaysian Journal of Nutrition, vol. 17, no. 2, pp. 271–276.
- Baroni L, Cenci L, Tettamanti M, Berati M. (2007). Evaluating the environmental impact of various dietary patterns combined with different food production systems. European Journal of Clinical Nutrition. 61 (2): 279–286. doi:10.1038/sj.ejcn.1602522.
- Dorota K (2015)Health Safety of Soft Drinks: Contents, Containers, and Microorganisms", BioMed Research International, vol. 2015, Article ID 128697, 15 pages, 2015. <https://doi.org/10.1155/2015/128697>.
- Ewaid, S.H., Kadhum, S.A., Abed, S.A., Salih, R.M. "Development and evaluation of irrigation water quality guide using IWQG V.1 software: A case study of Al-Gharraf Canal, Southern Iraq ; Environmental Technology and Innovation, (2019) 13, pp. 224-232

- Fazal-ur-Rehman M. Polluted Water Borne Diseases: Symptoms, Causes, Treatment and Prevention. (2019). *Journal of Medicinal and Chemical Sciences*, 2(3) 85-91. <http://dx.doi.org/10.26655/jmchemsci.2019.4.3>
- Fazal-ur-Rehman, M. Polluted Water Borne Diseases: Symptoms, Causes, Treatment and Prevention. (2019). *Journal of Medicinal and Chemical Sciences*, 2(1) 21-26. <http://dx.doi.org/10.26655/jmchemsci.2019.6.4>
- Frost P, Chen JC, Rabbani I, Smith J, Prasad AS. (1977)The effect of Zn deficiency on the immune response. In: Brewer GJ, Prasad AS, ed. Zinc metabolism: current aspects in health and disease. New York: Alan R Liss Inc, 1977:143–53.
- Gordeuk V, Mukiibi J, Hasstedt SJ, Samowitz W, Edwards CQ. (1992) Iron overload in Africa. Interaction between a gene and dietary iron content. *N. Engl. J. Med.* 326:95–100.
- Habre R, Coull B, Moshier E, Godbold J, Grunin A, Nath A, et al (2014) Sources of indoor air pollution in New York city residences of asthmatic children. *J Expo Sci Environ Epidemiol.* 2014;24:269–78.
- Jaishankar M, Tseten T, Anbalagan N, Mathew BB, Beeregowda KN (2014) Toxicity, mechanism and health effects of some heavy metals. *Interdiscip Toxicol*;7(2):60-72. doi:10.2478/intox-2014-0009.
- Ministry of Municipality, (2009). General Directorate for civilized Planning”, the basic design for Al Kufa City.
- Qu X, He Z, Qiao H, et al. (2018) Serum copper levels are associated with bone mineral density and total fracture. *J Orthop Translat.* 14:34-44. Published 2018 May 31. doi:10.1016/j.jot.2018.05.001.
- Rahmanian N, Siti Hajar Bt Ali, M. Homayoonfard, N. J. Ali, M. Rehan, Y. Sadeh, A. S. Nizami (2015) “Analysis of Physiochemical Parameters to Evaluate the Drinking Water Quality in the State of Perak, Malaysia”, *Journal of Chemistry*, vol. 2015, Article ID 716125, 10 pages, 2015. <https://doi.org/10.1155/2015/716125>.
- Ratkalkar VN, Kleinman JG (2011) Mechanisms of Stone Formation. *Clin Rev Bone Miner Metab.* 2011;9(3-4):187-197. doi:10.1007/s12018-011-9104-8.
- Rumana HS, Sharma RC, Beniwal V, Sharma AK. (2014) A retrospective approach to assess human health risks associated with growing air pollution in urbanized area of Thar Desert, Western Rajasthan, India. *J Environ Health Sci Eng.* 2014;12:23.
- Salman, A., Hussein (2010). Modification of the proficiency of water purification stations in Al Najaf in 2009, *Journal of College of Education for Human Sciences*, Volume (7,8), University of Kufa, 309.
- Siwila S, Chota C, Yambani K, et al (2017) Design of a small scale iron and manganese removal system for Copperbelt University’s borehole water. *J Environ Geol* 2017;1(1): 24-30.
- Soetan KO, Olaiya CO and Oyewole OE (2010) The importance of mineral elements for humans, domestic animals and plants: A review, *African Journal of Food Science* Vol. 4(5) pp. 200-222.
- Tchounwou PB, Yedjou CG, Patlolla AK, Sutton DJ. (2012) Heavy metal toxicity and the environment. *Exp Suppl.* ;101:133-164. doi:10.1007/978-3-7643-8340-4\_6.
- WHO, (2003) guidelines of drinking water. web site at [http://www.who.int/water\\_sanitation\\_health/dwq/chemicals/en/index.html](http://www.who.int/water_sanitation_health/dwq/chemicals/en/index.html).
- Zolnikov TR (2013) The maladies of water and war: addressing poor water quality in Iraq. *Am J Public Health.* 2013;103(6):980-987. doi:10.2105/AJPH.2012.301118.