Mesopo. Environ. J., Vol.4, No.4, pp. (34-47) 2018

**Mesopotamia Environmental Journal**
**ISSN 2410-2598**
Journal homepage http//:www.bumej.com

DOI: http://dx.doi.org/10.31759/mej.2018.4.4.0034

# Assessment of untreated wastewater used for crop irrigation in Khassa stream- Kirkuk/Iraq

**Thayer Y. Awad[1] , Awaz B. Mohammed[2] , Yassin M. Ahmed[1]**

. [1]College of science, University of Tikrit, Iraq

[2]College of science/University of Kirkuk,Iraq.

**Corresponding author:**bahrozawazz@gmail.com

**To cite this article:**

Thayer Y. Awad, Awaz B. Mohammed, and Yassin M. Ahmed. Assessment of untreated wastewater used for crop irrigation in Khassa stream- Kirkuk/Iraq. *Mesop. environ. j.*, 2018, Vol.4, No.4, pp: 34-47

Received date:21 /10/2018 accepted date: 21 /11/2018 published date:1/12/2018



## Introduction

The environmental pollution is a widespread problem facing major cities in developing countries over the past decades [1], the main forms of water pollution are wastewater from various human, agricultural, industrial and household activities [2]. The wastewater produced by different human activities varies, so it is difficult to establish fixed rates for their components [3]. It is composed of a dilute mixture of several types of contaminants, and the components depend on the sources they supply. Organic, inorganic and other substances in soluble, suspended, and colloidal state are the main components [4]. Pathogens associated with toxic waste and chemicals from these waters pose health risks for farmers, their families and communities living near wastewater, as well as consumers of crops irrigated with this polluted water [5].In the case of use of this water to irrigate crops, it should be ensured that they are free of high concentrations of harmful pollutants that affect the plant and soil directly or indirectly [6].In many regions, fresh water is not available for irrigation, therefore, reuse of treated or untreated wastewater is an alternative source of agriculture, however, standards are needed to ensure the safe use of wastewater and to avoid biological hazards to the population [7]. It has been suggested that the use of sewage in irrigation as

ISSN 2410-2598

one of the possible ways out of the looming water crisis [8].The use of sewage water for irrigation has additional agricultural benefits, It contains a high nutritional rate that can improve plant growth, reduce fertilizer use, increase poor soil productivity and fertility, increase soil organic matter, increase nutrient concentrations needed by plants such as nitrogen, phosphorus, iron, manganese, potassium, calcium, magnesium and others [9]. The need for this water for irrigation depends on the availability of dissolved salts, and the increased concentration of these salts and other components, they affect soil quality and make them less suitable for agriculture [11].Irrigation of these water effects on the soil at two different levels: the first change the physical and chemical properties and content of microorganisms of the soil, the second poses risks to human health and the environment, so sustainable wastewater reuse in agriculture can lead to both types of impacts, requiring a comprehensive and integrated risk assessment [12, 13]. In this study, the physical and chemical parameters of untreated wastewater were measured in the Khassa stream of Kirkuk City, which is used to irrigate crops located on the sides of the stream.The Khassa stream is one of the three main branches flowing into the Great River, the stream consists of rainwater, flood, and springs that originate from the mountains surrounding Sulaymaniyah city, this water accumulates in Kirkuk city and increases in winter seasons due to increased rainfall and floods. At present, the stream has become a passage for sewage only and running water suitable in the rainy season. The special tributary was chosen for its importance and it is the only stream that passes through Kirkuk city.

## Material and Methods

### Physical and chemical tests of water

Samples ofthe area of study is located in the Kirkuk city, which is about 240 km away from Baghdad, and it is one of the most important and vital cities in Iraq. The increase in population density and the spread of random houses, and the lack of fresh water bodies in Kirkuk are used for irrigation purposes, some farmers resort to irrigating their crops with untreated wastewater directly. The samples were collected monthly at the period from September 2017 to May 2018, Four sites were chosen were farmers using wastewater to irrigate their farms as illustrated in Fig. 1, in addition to these four sites a fifth site were selected as a control site:

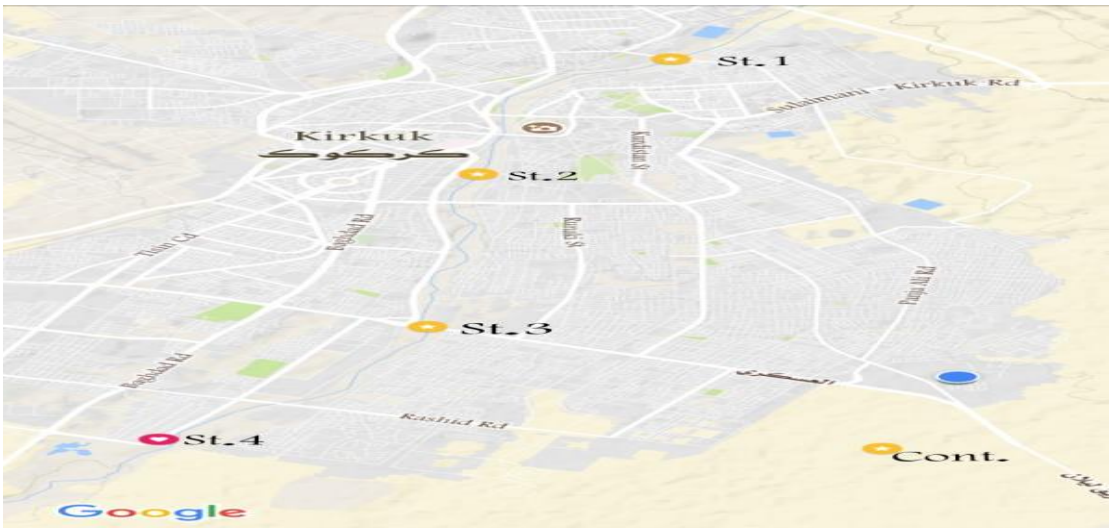


***Fig. 1:*** Map of the study sites

ISSN 2410-2598

-The first site: It is located in the Karama area near the Azadi Bridge, where the rainwater is discharged, in addition to the absence of treatment plants.

- The second site: located in the Al-Mussallah area and away from the first site (3600) meters, was selected to provide sewage from markets, restaurants and hotels.

- The third site located in the Al-Askry district and away from the second site (5500) meters.

- The fourth site is located in Al-Sayeda area, and there is a lot of buffalo breeding in this area.

- The fifth site (control site) located in the area of Benga Ali, and away from the Khassa stream (5000) meters, the farmers in this area used well water for irrigation their farms, this site was chosen because of its distance from the Khassa stream.

Each of [TDS, COD (Open Reflux Method), phosphates (Ascorbic Acid method), sulphates (Turbidimetric method), nitrates (Ultraviolet Spectrophotometric Screening method), chlorides (Argentometric method), sodium (Flame Atomic Emission method), magnesium and calcium (EDTA Titrimetric method)] were measured according to [14]. The turbidity was measured by (TR 210 IR) device, and the EC and TDS of the water samples were measured using a multi meter (HANNA Hi 99300) device, pH used (pH Meter 720), the (Senso Direct 150) device is used to measure the dissolved oxygen, and the (OxiTop) device for BOD measurement, potassium was measured using a (HANNA) kit.

## Statistical analysis

Statical analysis has been conducted by using the Special Program for Statistical System (SPSS), Duncan test to compare averages, and Person Correlations.

## Results and Discussion

## Physico-chemical characteristics of wastewater under study

Figures (2,3,4) and tables 1 and 2 summmmerized the results of the study and statistical analysis and comparison witheiraqi and international standards. Figure2 shows the levels of turbidity, EC,Total dissolved solids (TDS), Total suspended solids (TSS), pH and Dissolved oxygen (DO). The turbidity of the raw sewage was varied according to the various human activities and rainfall, the highest rate of turbidity was (196NTU) at the second site during spring, while the lowest rate (15.9NTU) was recorded at control site of autumn . The increase in turbidity rates during the rainy seasons was due to the increase in the water level due to the precipitation with which a quantity of the river was washed [14], the decrease of rates due to the water of the control site is relatively stagnant.

ISSN 2410-2598

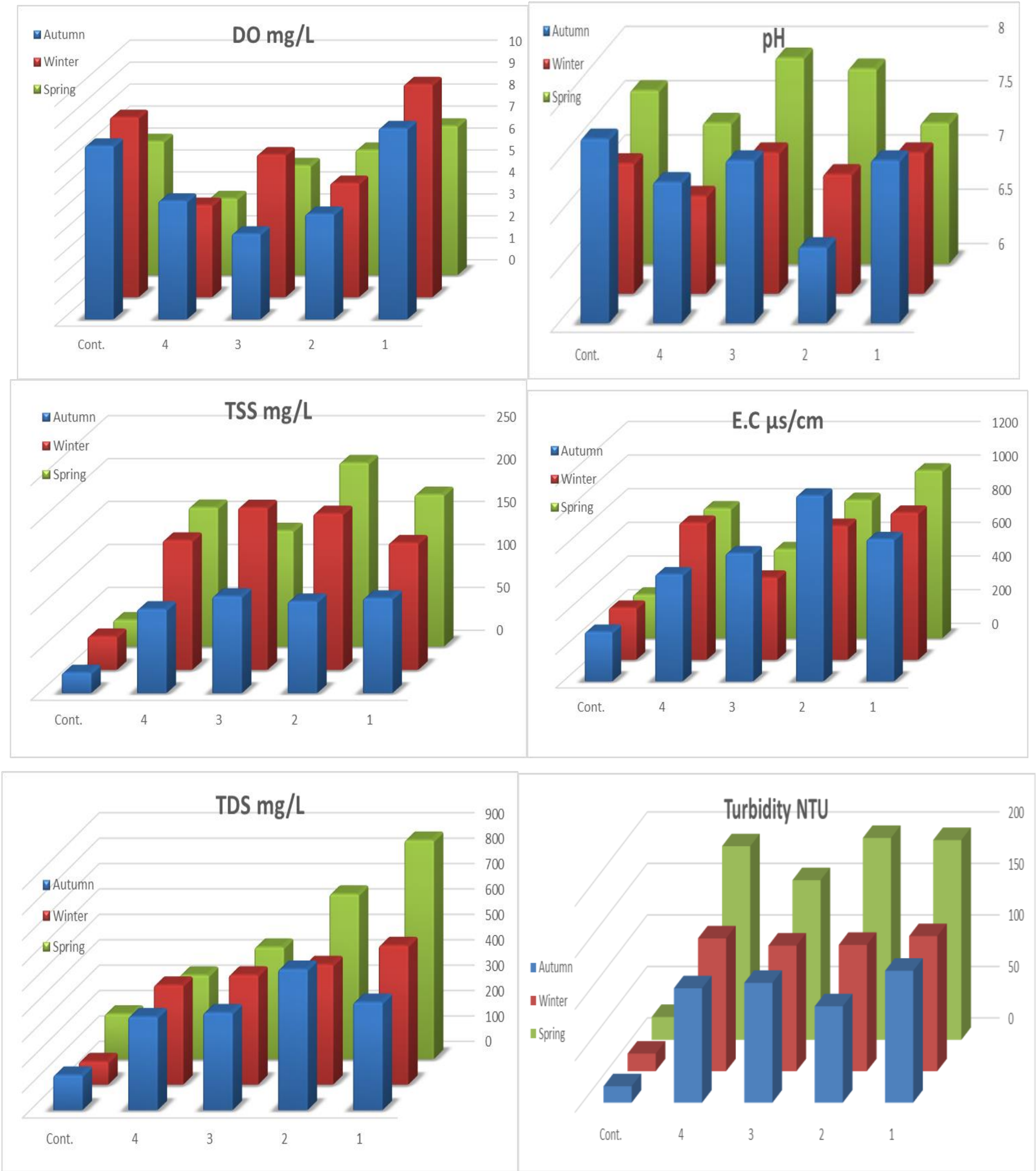


***Fig. 2:*** Values of (Turbidity, E.C, TDS, TSS) at the studied sites.

***Table 1.***Statistical analysis of Physico- chemical charactiristics of wastewater samples under study

.

| Seasons / Tests | Autumn | Winter | Spring |
|---|---|---|---|
| Turb.(NTU) | c92.94 | b104.4 | a151.04 |
| E.C(μs/cm) | a729 | c657.2 | b676.8 |
| TDS(mg/L) | c374 | b387.2 | a492.4 |
| TSS(mg/L) | c90.53 | b141.8 | a143.8 |
| pH | b7.34 | c7.16 | a7.58 |
| DO(mg/L) | b6.14 | a6.76 | c5.42 |
| COD(mg/L) | a362 | c285.4 | b314.2 |
| BOD(mg/L) | a157.2 | c136.8 | b141.6 |
| $PO_4$(mg/L) | b3.48 | a5.34 | c2.49 |
| $SO_4$(mg/L) | b225.53 | a234.04 | c182.93 |
| $NO_3$(mg/L) | a17.8 | b17.58 | c12.16 |
| Cl(mg/L) | b42.58 | c36.96 | a43.17 |
| K(mg/L) | b6.5 | a6.9 | c6.07 |
| Na(mg/L) | b26.47 | a28.11 | b25.86 |
| Ca(mg/L) | b50.4 | a52.9 | a53.1 |
| Mg(mg/L) | a36.9 | c18.1 | b29.6 |

Electrical conductivity (EC) is the ability of a medium, such as water, to carry an electric current, the presence of soluble solids such as calcium, chloride and magnesium in water samples increase water electrical conductivity [15]. The rates of EC were ranged between (1105μs/cm) at the second site of the autumn and (260μs/cm) at the control site of spring. The rise in the rates of EC is due to the nature of liquid precipitates discharged into the stream [16].

Total dissolved solids (TDS) concentrations depend on water sources, and water passing through soluble mineral soils has higher levels of TDS [17]. The highest rate of TDS was (862mg/L) at the first site of spring season, and the lowest rate was (91mg/L) at the control site of autumn season. According to [18] high levels of TDS in wastewater discharge has a negative impact on aquatic life and reduces crop yields if used in irrigation [19]. Noted that low concentrations of soluble salts might be attributed to specific rock formations of water.

Total suspended solids (TSS) are substances in water that do not pass through a filter paper of 0.45 microns [20]. TSS highest rate was (214mg/L) at the second site of spring season and the lowest rate was (24mg/L) at the control site of autumn season. Increases rate in spring season is result from precipitation and rising water levels that washed away the soil [21]. The low rates are due to the relatively stagnant water at control site. pH is a chemical concept used to determine the amount of hydrogen ion concentration in water [22]. The highest rate was (7.9) at the third site of spring season while the lowest rate was (6.7) at the second site of autumn season. All rates were converged during the months of the study and tend to light basal, low pH rates may be due to sulfate salts, nitrates and chlorides with acidic effect.The higher rates are due to the increased discharge of domestic sewage water loaded with basal detergents [23, 24].

Dissolved oxygen (DO) is necessary for all living organisms and for many chemical processes occurring within water, and water content of oxygen is an important factor [13]. The highest rate of DO was (9.7mg/L) at the first site of winter season while the lowest rate was (3.5mg/L) at the fourth site of spring season. The higher DO rates which may be due to photosynthesis process of algae and their release to oxygen as a by-product [25], while the fourth site recorded the lowest rate of the DO due to the large number of organic matter produced from buffalo breeding at this site.

***Table 2.*** Iraqi and international standards of irrigation water.

Figure 3 shows the results reorded for Chemical oxygen demand (COD), Biological Oxygen Demand (BOD), phosphorus, Sulphate ($SO_4$) , Nitrates ($NO_3$) and Chloride (Cl). Chemical oxygen demand (COD) is an indirect measure of

| **Tests** | **Iraqi Determinants of Water for Irrigation1998** | **WHO 2004** | **Canadian standard(2003)** | **USEPA(2002)** | **Current Study mini-max** |
|---|---|---|---|---|---|
| Turbidity(NTU) | 25 | 0-50 | - | - | 15.9-194 |
| EC(µs/cm) | - | 1350 | 1600 | 1600 | 260-1150 |
| TDS(mg/L) | 1000 | 500-1500 | 450 | 1000 | 91-862 |
| TSS(mg/L) | 40 | 1000 | - | - | 24-214 |
| pH | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | 6.7-7.9 |
| DO(mg/L) | <5 | <5 | 4-6.5 | - | 3.5-9.71 |
| COD(mg/L) | <40 | - | - | - | 0-712 |
| BOD(mg/L) | <10 | <3 | - | - | 0-267 |
| $PO_4$(mg/L) | 25 | 0.4 | - | 0.5 | 0.14-9.57 |
| $SO_4$(mg/L) | 200 | 150-250 | 400 | 500 | 109-349 |
| $NO_3$(mg/L) | 25 –50 | 0 – 45 | 10 | 45 | 6.26-32.26 |
| K(mg/L) | 100 | 12 | - | - | 5.2-9.1 |
| Na(mg/L) | 250 | 200 | 200 | 200 | 14.32-42.58 |
| Ca(mg/L) | 25-50 | 75 | 25 | 50 | 30.4-87.11 |
| Mg(mg/L) | 80 | 50-125 | 50 | 125 | 13.19-67.98 |

the amount of contaminants that cannot be oxidized biologically in a water sample, the high COD rates indicate a high amount of contaminants [8]. Both organic and inorganic pollutants are subject to this oxidation, and the organic pollutants are more important [13]. COD were recorded highest rate (712mg/L) at the fourth site of autumn season, while no rate was recorded at the control site of spring season [26]. Noted that the COD rates are affected by the presence of organic matter, dissolved solids and due to industrial and household waste and agricultural activities. The BOD is defined as the amount of oxygen needed by microorganisms to analyze unstable organic matter found in water and turns it into a more stable state under aerobic conditions [13]. The highest rate was (267mg/L) at the fourth site of autumn season while no value was recorded at the control site in spring. The BOD's high values may be due to the flow of organic matter and organic fertilizers used for agricultural land adjacent to the stream [27]. The low concentration of the BOD at the control site are due to the filtration processes that get the water to the groundwater at the control site, the soil layers are either isolated or far from the outside, so they are fairly clean [28].

The main sources of phosphorus are local wastewater, detergents, agricultural effluents with fertilizers and industrial wastewater, the higher concentrations of phosphorus indicate pollution [26]. The highest rate of phosphate was (9.57mg/L) at the third site of winter season, while the lowest rate was (0.14mg/L) at the control site of spring season. The decrease in phosphate rates in the control site is due to the arrival of small quantities of contaminants containing wastewater or phosphorus-containing agricultural wastes, the increase in phosphate levels is due to the high concentration in the wastewater resulting from the use of detergents from powders and cleaning fluids, human consumption has increased its concentrations in wastewater and varies according to the intensity and quantity of these uses [29].

Sulphate ($SO_4$) ions are present in different concentrations ranging from a few milligrams to thousands of milligrams per liter depending on the geological nature of the water sources [13]. The highest rate of sulphate was (349mg/L) at the fourth site of winter season, while the lowest rate was (109.24mg/L) at the control site of spring season. The increase in sulfur levels in winter is due to the discharge of wastewater and water from agricultural lands [29, 30]. Shows that sulfur rates are increasing in areas where household wastewater is liquidities due to anaerobic degradation of compounds. Nitrates ($NO_3$) are the most abundant form of nitrogen compounds normally found in natural waters, important nitrate sources are chemical fertilizers, degraded plant and animal materials, and wastewater disposal [31]. $NO_3$ recorded the highest rate (32.29mg/L) at the third site of autumn season, while the lowest rate was (6.26mg/L) at the control site of spring season. The high concentration of nitrate is due to the discharge of water from fertilizer-rich agricultural lands and animal residues, the proximity of farmland provided by river water species to chemical and animal fertilizers has increased nitrate concentrations [32]. Low rates may be due to increases in photosynthesis rates by phytoplankton as well as increased nitrate reduction [33].

***Table 3.*** Statistical analysis for physio-chemical characteristic used for irrigation at studied sites.

| | **site.1** | **site.2** | **site.3** | **site4** | **cont.** |
|---|---|---|---|---|---|
| **Turbidity(NTU)** | a151.07 | c137.4 | d131.1 | b142.67 | e18.4 |
| **EC(µs/cm)** | b906.33 | a908.33 | d593.67 | c741.67 | e288.33 |
| **TDS(mg/L)** | a611.67 | b559.33 | c419 | d363.67 | e135 |
| **TSS(mg/L)** | b145.22 | a167.67 | b145.67 | c137 | d31.33 |
| **pH** | bc7.37 | cd7.2 | a7.67 | d7.27 | ab7.5 |
| **DO(mg/L)** | a8.4 | c5.23 | c5.13 | d4.37 | b7.4 |
| **COD(mg/L)** | d254 | c349.7 | b385 | a596.3 | e17.67 |
| **BOD(mg/L)** | d127.67 | c168.67 | b186.67 | a242.3 | e0.67 |
| **$PO_4$(mg/L)** | b5.47 | d2.67 | a6.67 | c3.81 | e0.26 |
| **$SO_4$(mg/L)** | c212.87 | d160.87 | b251.67 | a299.7 | e145.87 |
| **$NO_3$(mg/L)** | c14.94 | d14.39 | b20.64 | a21.04 | e8.23 |
| **Cl(mg/L)** | d34.31 | b50.19 | c49.02 | a57.63 | e13.37 |
| **K(mg/L)** | ab6.67 | a6.65 | ab6.38 | a6.81 | b6.27 |
| **Na(mg/L)** | b31.89 | c25.39 | a37.5 | d22.69 | e16.7 |
| **Ca(mg/L)** | a76.98 | c47.2 | e35.19 | b63.1 | d38.3 |
| **Mg(mg/L)** | a44.57 | c25.5 | e19.29 | b28.4 | d23.2 |

ISSN 2410-2598

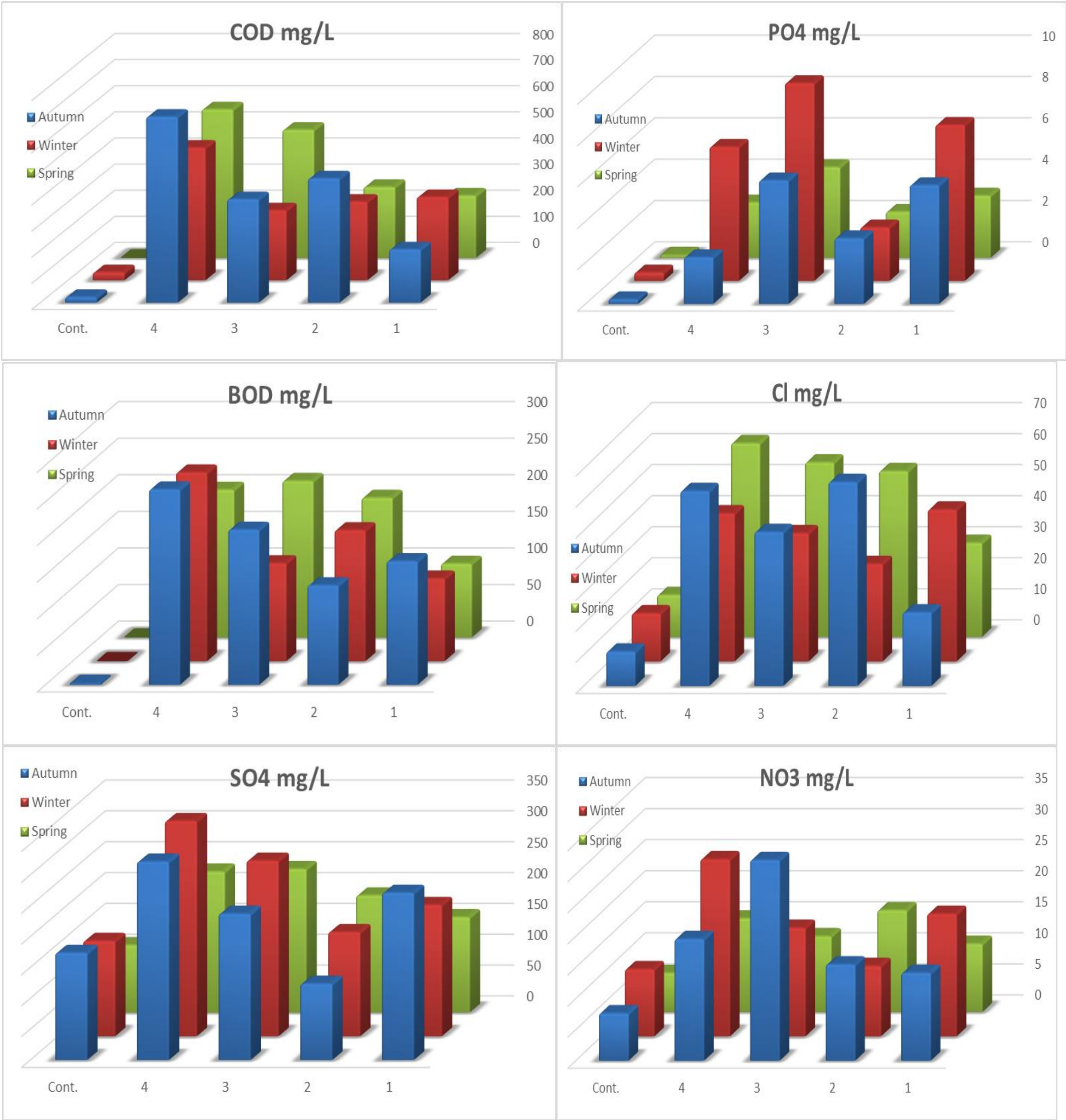


***Fig. 3:*** Values of (COD, BOD, $SO_4$, $NO_3$ , $PO_4$ ,Cl,) in the studied sites.

Chloride (Cl) ion is available in most of the water at different concentrations, sedimentary rocks are an important source of this ion in water as well as industrial, domestic, and domestic waste water to the watercourse [34] this is confirmed by [35]. Highest and the lowest rate of chloride was (65.7- 11.1mg/L) at the second site and control site respectively. Low chloride rates at the control site may indicate that the soil surrounding the site is low in chloride, and that the depth of the water at control site and its distance from rainwater and surface water have led to a lack of concentration Chloride in this site.

We observe in Figure4 the results of Potassium ion (K), Sodium ion (Na) , Calcium (Ca) and Magnesium (Mg). Potassium ion (K) is found in a few concentrations in natural water because the rocks contain resistance to weathering, but its salts are widely found on industrial scale and agricultural fertilizers [35]. The natural concentration of potassium in irrigation water is between (0-2mg / L) [36]. The current study recorded the highest rate of potassium (9.1mg/L) at the third site of winter season, while the lowest rate was (5.2mg/L) at the control site of winter season. The decrease in potassium rates may be attributed to the paucity of agricultural activities, as well as the lack of decaying plant residues that add potassium ions to the water [37]. The higher rates are due to the introduction of untreated water as well as to the potassium-containing agricultural water discharge [38]. Sodium ion (Na) is a positive ions in the earth's crust and usually united with many ions as a stable salts [39], and it is one of the most common metals in the Earth's crust [40]. Na recorded the highest rate (42.58mg/L) at the third site of autumn season, while the lowest rate was (14.32mg/L) at the control site of autumn season. Variable rates of Na in the wastewater may be due to the different amounts of pollutants added to the river from household waste and the agricultural effects of surrounding lands [41], as well as sewage loaded with sodium ions [25]. The reduction of sodium concentrations in some areas of the study is due to the removal of this element by adsorption of the living organisms.Calcium (Ca) is an essential element for plant growth [42]. Its presence in irrigation water is essential for the natural growth of the plant and also improves soil permeability and minimizes the harmful effect of sodium [43]. The highest rate of calcium was (87.11mg/L) at the first site of the spring season while the lowest rate in the third site for the fall season (30.41mg/L),

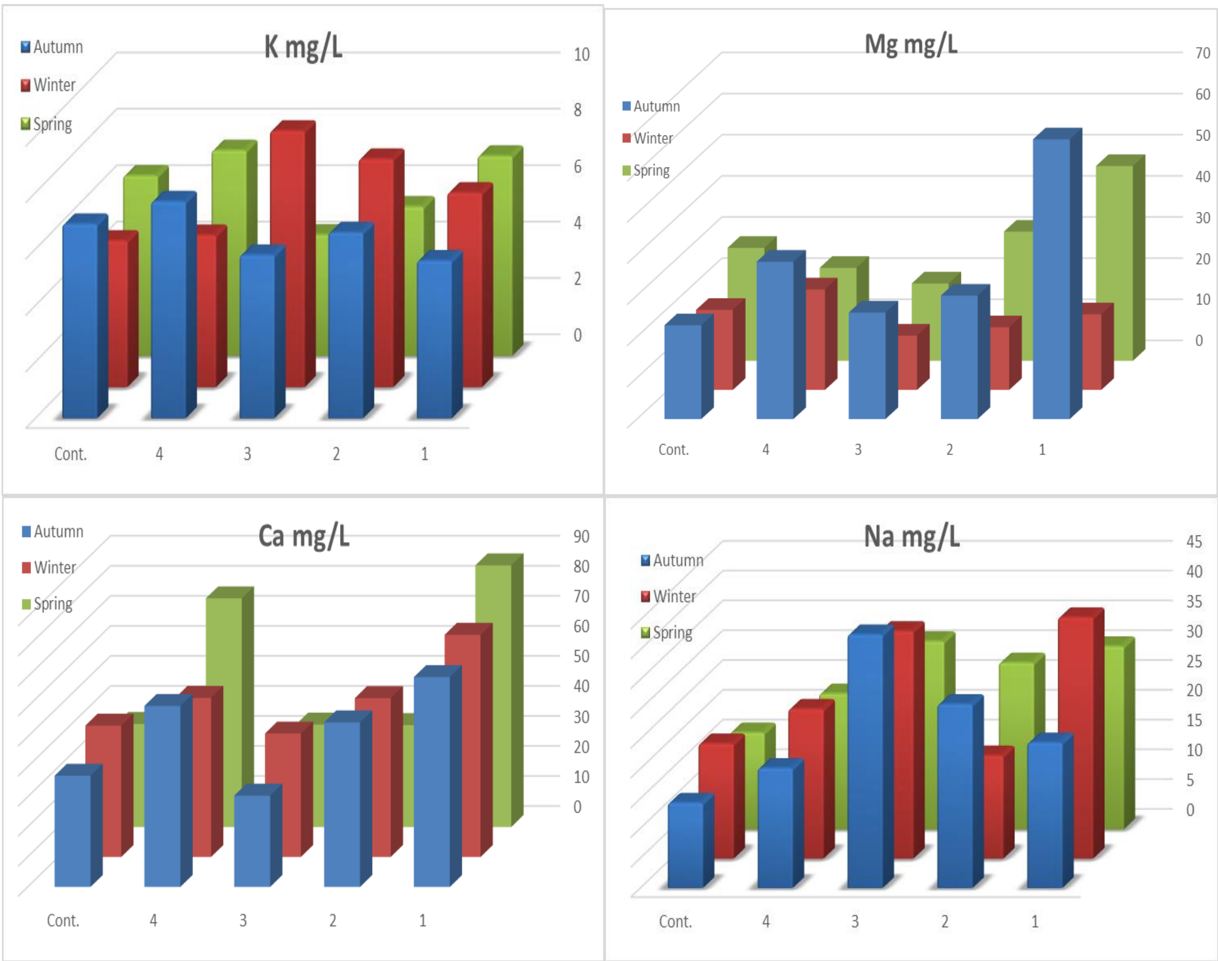


***Fig. 4:*** Values of (K, Na, Ca, Mg) in the studied sites.

The rise in calcium values due to the precipitation of these ions from adjacent areas, as reported by [44], as well as the rise of calcium concentrations in domestic wastewater and detergents and plant residues [41], the reason for the decline in the rate of calcium in some months is due to the need of some water organisms to use this element in their life activities to build some of its members or deposition to form compounds that are not soluble in water [45].

Magnesium (Mg) is a widespread element found in nature and appears primarily with calcium in geological formations as well as in dissolved water, magnesium in water can be a natural source, but it also refers to human contamination with sewage or agricultural fertilizers [36]. Magnesium is less soluble than calcium because it can be deposited in large amounts [46]. The highest Mg rate was recorded was (67.98 mg/L) during the autumn season at the first site and the lowest was (13.19mg/L) at the third site of the winter season. Low of Magnesium concentration may be due to immediate causes or precipitation. The salinity of the water increases when the presence of magnesium ions in greater quantities. The variation in the rates of magnesium may be due to the geological nature of the study area [41 and 47]. There were significant differences regarding seasons of the study for all physical and chemical tests, and significant differences were found among studied sites except for pH and DO, while no significant differences was resulted for potassium at contaminated sites. The results of (EC, TDS, TSS, pH, PO4, NO3, K, Na, and Mg) were within the permissible limits for irrigation except for (Turbidity, DO, COD, BOD, SO4, and Ca) which exceeded permissible limits.

## Conclusions

Local agriculture is one of the most important wastewater consumers, and the search for alternative irrigation sources is necessary to ensure the safety of crops. The use of wastewater as an alternative source of irrigation is a mechanism that works because of the scarcity of water sources for irrigation in some countries. However, there are risks associated with this use that should be evaluated. These risks range from altering the physical and chemical properties of soil to human health.

## References

1. **WHO.**Bitumens and bitumen emissions and some N- and S- Heterocyclic aromatic hydrocarbons, Vol.103, International agency for research and cancer, France.2013.

2. **Adedosu, T.A.; Adeniyi, O.K. and Adedosu, H.O**. Distribution, Sources and Toxicity Potentials of Polycyclic Aromatic Hydrocarbons in Soil round the Vicinity of Balogunb-Birro, Nigiria. Malaysian Journal of Analytical Sciences, Vol.19,No.3,pp.636 – 648. 2015.

3. **Elgallal, M.M.**Development of an approach for the evaluation of wastewater reuse options for arid and semi-arid area. Ph D Thesis submitted to School of Civil Engineering, University of Leeds.2017.

4. **Yong,** C. New technology for wastewater treatment Degree Programme, Centria University of applied sciences.2017.

5. **Dickin, S.K.; Schuster-Wallace, C.J.; Qadir, M. and Pizzacalla, K.** A review of health risks and pathways for exposure to wastewater use in agriculture. Environmental Health Perspectives,Vol.124,No.7.pp. 900–909.2016.

6. **Amerasinghe, P.; Bhardwaj, R.M.; Scott, C.; Jella, K. and Marshall, F.** Urban wastewater and agricultural reuse challenges in India. Colombo, Sri Lanka: International Water Management Institute (IWMI). 36p. (IWMI Research Report 147).2013.

7. **Gatica, J. and Cytryn, E.** Impact of treated wastewater irrigation on antibiotic resistance in the soil microbiome. Environmental Science and Pollution Research, Vol.20,No6,pp. 3529–3538.2013.

8. **UNESCO** (United Nations Educational, Scientific and Cultural Organization. Wastewater: The untapped resource, 7, place de Fontenoy, 75352 Paris 07 SP, France.2017.
9. **Jaramillo, M.F. and Restrepo, I.** Wastewater Reuse in Agriculture: A Review about Its Limitations and Benefits. Instituto CINARA, Facultad de Ingeniería, Universidad Del Valle, Cali 760032, Colombia.2017.

10. **Dhembare, A. J.** Assessment of Water Quality Indices for Irrigation of Dynaneshwar Dam Water, Ahmednagar, Maharashtra, India, Scholars Research Library. Vol. 4,No.1,pp.348-352.2012.

11. **Becerra-Castro, C; Lopes, A.R.;Vaz-Moreira,I.;Silva, E.F.;Manaia, C.M. and Nunes, O.C.**.wastewater reuse in irrigation : A microbiological perspective on implication in soil fertility and human and environmental health , Environment International. Vol.75,pp.117-135.2015.

12. **Mukherjee, V.; Das, A.; Akhand, A. and Gupta, G.** Toxicity and profitability of rice cultivation under wastewater irrigation: the case of the East Calcutta Wetlands. Ecological Economics.Vol: 93, pp.292-300.2013.

13. **APHA** (American Public Health Association). Standard Methods for the Examination of Water and Wastewater 23$^{th}$ Edition, 800 I Street, NW, Washington DC, USA.2017.

14. **Al-Sarraf, M. A.** Comparative Environmental Taxonomic Study of Plant Entomology in Rafidi, Diyala and their Influence on the Tigris River, PhD Thesis, Faculty of Science, University of Baghdad. 2006.

15. **Lukubye, B. and Andama, M.** Bacterial Analysis of Selected Drinking Water Sources in Mbarara Municipality, Uganda. Journal of Water Resource and Protection. Vol. 09,No.8,pp. 999–1013.2017.

16. **Al-Safawi, A. Y. and Al-Maaadidi, A. T.** Qualitative Evaluation of the Sedimentary Properties of WadiAkab, Northern Mosul City for Irrigation, Tikrit University Journal of Pure Sciences, Vol.22,No.12.2017.

17. **Al-Helaly, S.H.** An Investigation of Some Heavy Metals in Water, Sediment and Some Biota of Al-Gharraf River, South of Iraq, master thesis, College of Science, University of Baghdad.2010.

18. **Paul, W.** Impact of Industrial Effluents on Water Quality of Receiving Streams in Nakawa-Ntinda, Uganda, 1–68.2011.

19. **Al-Jubouri, M.A.** The water shape of the Tigris River between the mouth of the Zabin and his investments in Iraq, a study in natural geography, PhD thesis, Faculty of Education, University of Mosul.1998.

20. **Lawson, E.O.**Physico-chemical parameters and heavy metal contents of water from the mangrove swamps of Lagos Lagoon, Nigeria. Advan. Biol. Res. Vol.5,No.1,pp. 8-21.2011.

21. **Al-Dahimi, M.H.** Detection of some environmental pollutants using some aquatic organisms. Master Thesis, Faculty of Science, University of Babylon, Iraq.2006.

22. **Alley**, E.R. Water quality control handbook. The McGraw-Hill Companies, New York.2007.

23. **Norby, J.G.** The origin and the meaning of the little p in pH, Trends in Biochemical Sciences.2000.

24. **Al-Musawi, A. and Hussein, N.A.** Physical and chemical properties of the southern marshes in Iraq. Iraq Marshlands Environmental Studies, Publications of the Center for Marine Sciences.1994.

25. **Sahoo, M.; Mahananda, M R. and Seth, P.** Physico-Chemical Analysis of Surface and Groundwater around Talcher Coal Field ,. Journal of Geoscience and Environment Protection, Vol.4,(February),pp. 26–37.2016.

26. **El-Amier, Y.A.; Zahran, M. A. and Al-mamory, S.H.** Assessment the Physico-Chemical Characteristics of Water and Sediment in Rosetta Branch , Egypt. Journal of Water Resource and Protection, 7(September), 1075–1086.2015.

27. **Saeed, S. H.; Abdul Jabbar, R.A. and Sharif, H.A.** The validity of well water for a drink in the city of Kirkuk and its environs, Iraq, Tikrit Magazine for Pure Sciences, Vol.22,No.10.2017.

28. **Al-Obeidi, M.A.** Environmental study on the quality of groundwater in the district of Al-Tawz and its villages, Master Thesis, Faculty of Science, University of Tikrit.2014.

29. **Al-Mayah, W.T.** Effect of domestic sewage on water quality of Al-Gharraf River in Al-Haay city, master thesis, College of Science, University of Baghdad. 2013.

30. **Al - Jarjari, S.N.** Study of the effect of oil residues on some developing plants in the governorates of Kirkuk and Salah Al-Uddin, Master Thesis, Faculty of Science, University of Tikrit.2013.

31. **Al-Zamili, H.A.** Effect of local domestic sewage in water quality of Al-Dujaila River in Al-Kut city/ Iraq, master thesis, College of Science University of Baghdad.2014.

32. **Tank, S.K. and Chippa, R.C.** Analysis of Water Quality of Halena Blocks in Bharatpur. International Journal of Scientific and Research Publications, Vol.3,pp.1-6.2013.

33. **Al-Nemrawi, A.M.** Studying the biological diversity of zooplankton and invertebrates in the Tigris and Euphrates rivers in central Iraq, PhD thesis, Faculty of Science, University of Baghdad.2005.

34. **Ezeribe, A.I.; Oshieke, K.C. and Jauro, A.**Physico-chemical properties of well water samples from some Villages in Nigeria with cases of stained and mottle teeth. Sci. World J. Vol.7,No.1.2012.

35. **Chapman, D.** Water Quality Assessments - A guide to use of biota, sediments and water in enviromental monitoring. University Press, Cambridge ISBN, Vol.2, No.1,pp 609. 1996.

36. **Kaufmann, D.**Mobile drinking water purification for developing countries Master-Thesis, Department of Civil Engineering, University of Applied Sciences in Trier, Germany, 1589394(952451).2016.

37. **Al-Falaawi, F.K.** Study of the quality of drinking water in some drinking water treatment plants in Baghdad, PhD thesis, Faculty of Science, University of Baghdad.2009.

38. **Mustafa, O.M.** Impact of Sewage Wastewater on the Environment of Tanjero River and Its Basin within Sulaimani City/NE-Iraq, master thesis, College of Science, University of Baghdad.2006.

39. **Xiao, J.; Jin, Z-D; Ding, H.; Wang, J. and Zhang, F.** Geochemistry and solute sources of surface waters of the Tarim River Basin in the extreme arid region, NW Tibetan Plateau. Journal of Asian Earth Sciences, Vol.54–55,pp: 162–173.2012.

40. **Fritsch, P.; Hoch, W.; Merkl, G.; Ottilinger, F.; Rautenberg, J.؛Weiß, M. and Wricke, B.**Mutschmann/Stimmelmayr. Taschenbuch der Wasserversorgung. 16.,vollst. Überarb. undaktual. Auflage 2014. Springer Vieweg.Wiesbaden, Germany.2014.

41. **Zangana, B.M.** Study of physical and chemical properties and heavy metals pollution in DiyalaRafid, PhD thesis, College of Education for Pure Sciences, University of Tikrit.2016.

42. **Bamakanta, G.; Sunakar, P.; Satyabhma, T. and Prased, T.U.** Seasonal variation of Nagavali River water quality at the vicinity of paper mill near Jaykaypur, Odisha, India.Int. Res. J. Environment Sci.Vol. 2,No.5,pp. 46-52.2013.

ISSN 2410-2598

43. **Al_Obeidi, O.H.** Study and evaluation of the causes of salinity of the Euphrates River in Central and Southern Iraq, Master Thesis, Faculty of Agriculture, Al-Muthanna University.2017.

**44. Stevens, M.R.** Water quality and trend analysis of Colorado –Big Thompson System reservoirs and related conveyances 1996 through 2000.Water Resources Investigations Report.2000.

45. **Atta, B.M.; Saeed, B.A. and Ahmed, H.** Evaluation of the Efficiency of the Wastewater Treatment Unit in the Residential Complex / Floor Salahuddin, Tikrit Magazine for Pure Sciences, Vol.22,No.5.2017.

46. **Allen, J.; Robert, D. R. and Jonathan, W.** Practical skills in environmental science. Pearson Education Asidptelted, Singapore..2000.

47. **Abdel-Jabbar, Riad, A and al-Obeidi, H.H.** Study of Some Physical and Chemical Properties of Groundwater in Al-Sharqat District, Tikrit Journal of Pure Sciences, Vol.16,No.3.2011.

48. **IraqiEnvironmentallegislations**. Department of protecting and improving the environment in Iraq.1998.

49. **WHO** (World health organization).Guidelines for Drinking water quality (3rd .Ed) Geneva. 2004.

.

50. **USEPA** (United State – Environmental Protection Agency). Ground water and drinking water standards: National primary drinking water regulation. 816-F: 02-03.2002.

51. **CEOH** (Committee on Environmental and Occupational Health (Canada))..Desmet, W.H. and Evens, M. J. (1972). “A Hydro biological study of the polluted river leive (Ghent, Belgium). Hydrobiologia. Vol.39,pp.91-154.2003.