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Study of the Concentration of Some Pollutants in reject brine from Water Purification Plants in Tajoura, Libya

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دراسة تركيز بعض الملوثات في المحلول الملحي الناتج من محطات تنقية المياه في تاجوراء، ليبيا

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Abstract:
The study was conducted in Tajoura (21 km east of Tripoli) from the end of December 2022. Fourteen samples were collected from various stations in the study area. After conducting the necessary analyses and comparing the results with international standards, it was discovered that most of the stations examined exceeded the permitted limits for treated wastewater. The total dissolved salts in the wastewater ranged between 286.3 and 11,286.7 mg/L, while the concentration in the well water varied from 70 to 6,545 mg/L. Additionally, chloride concentrations in the water were found to be as high as 6,742.6 mg/L, with a sodium concentration of 1,719.0 mg/L. These results clearly show that wastewater from water purification plants is a significant source of environmental pollution due to its high pollutant concentration. Therefore, it is crucial for the relevant authorities to monitor the stations and require the implementation of treatment units to process the wastewater generated by these plants before it is released into the environment. This is important because the damage caused by these pollutants to the environment highlights the need to consider the environmental aspect when establishing water purification plants. Consequently, environmental impact assessments should be conducted during the planning process, appropriate technologies should be selected, and environmentally friendly materials should be utilized in the operation of these stations.

Keywords: water purification plants, chemical analysis, physical analysis, reject brine, pollutants.

الملخص
أجريت الدراسة في تاجوراء (21 كم شرق طرابلس) اعتبارًا من نهاية ديسمبر 2022. تم جمع أربعة عشر عينة من محطات مختلفة في منطقة الدراسة. بعد إجراء التحاليل اللازمة ومقارنة النتائج بالمعايير الدولية، تبين أن معظم المحطات التي تم فحصها تجاوزت الحدود المسموح بها لمياه الصرف الصحي المعالجة. تراوح إجمالي الأملاح الذائبة في مياه الصرف الصحي بين 286.3 و 11286.7 ملغم/لتر، بينما تراوح التركيز في مياه الآبار من 70 إلى 6545 ملغم/لتر. بالإضافة إلى ذلك، وجد أن تركيزات الكلوريد في المياه تصل إلى 6742.6 ملغم/لتر، مع تركيز صوديوم قدره 1719.0 ملغم/لتر. تُظهر هذه النتائج بوضوح أن مياه الصرف الصحي من محطات تنقية المياه هي مصدر مهم للتلوث البيئي بسبب تركيز الملوثات العالي فيها. لذلك، من الضروري أن تقوم الجهات المعنية بمراقبة المحطات والمطالبة بتنفيذ وحدات معالجة لمعالجة مياه الصرف الصحي الناتجة عن هذه المحطات قبل إطلاقها في البيئة. هذا مهم لأن الضرر الذي تُلحقه هذه الملوثات بالبيئة يُبرز

ضرورة مراعاة الجانب البيئي عند إنشاء محطات تنقية المياه. لذا، ينبغي إجراء تقييمات الأثر البيئي أثناء عملية التخطيط، واختيار التقنيات المناسبة، واستخدام مواد صديقة للبيئة في تشغيل هذه المحطات.

الكلمات المفتاحية: محطات تنقية المياه، التحليل الكيميائي، التحليل الفيزيائي، محلول ملحي مرفوض، الملوثات.

1. Introduction:

The rejected brine is a by-product of various sectors, including desalination plants, oil and gas, petrochemical, textile, and steel production. It has a salinity that is 1.6x to 2x higher than seawater [1,2]. Typically, the daily amount of rejected brine is 45-70% of the feed saltwater [3]. Brine is usually discharged into the environment through methods such as ocean/surface water discharge, evaporation ponds, sewage discharge, among others [4-6]. Regardless of the type of desalination plant, the discharge of rejected brine into saltwater is a significant environmental problem due to its high salinity, high temperatures, and the presence of toxic and non-toxic leftover compounds from pre-treatment processes. Consequently, the rejected brine can harm marine and subsurface ecosystems, cause eutrophication, pH oscillations, and increase heavy

metal levels in the marine environment [7-9]. Various treatment approaches are currently being used, but these strategies are no longer sustainable [10].

The rejected brine is considered a potential source because it contains important components like Na+ and Cl- [10]. Sustainable brine management is crucial to ensure environmental and human safety because brine is difficult to treat or dispose of due to its dynamic composition and purification requirements [2,11].

Water purification plants play a critical role in removing pollutants from wastewater and ensuring the safety of water resources. However, the presence of emerging pollutants in wastewater has raised concerns about the effectiveness of treatment processes. Studies have focused on determining the concentration of pollutants in influent and effluent from wastewater treatment plants (WWTPs) to assess the efficacy of water purification [12]. Analysing pollutant concentrations in the solid phase (particulate) water has also been a significant area of study to evaluate the potential environmental impact.

Water purification plants are vital for removing toxins from wastewater and ensuring the safety of water supplies. However, the presence of emerging contaminants in wastewater raises concerns about treatment effectiveness. Studies have focused on quantifying contaminant concentrations in influent and effluent from wastewater treatment plants (WWTP) to better understand water purification efficacy [12]. Analysing pollutant concentrations in the solid phase of water has also been important for estimating potential environmental impact. Moreover, research has investigated the persistence of pharmaceutical chemicals and other organic wastewater pollutants in traditional drinking-water treatment plants. Advances in water treatment processes are needed to successfully remove these pollutants. A study on the stepwise removal of micro-litter in tertiary-level wastewater treatment plants was conducted to understand average concentration and removal during the treatment process [13].

The results of these studies have significant implications for water quality management and environmental preservation. Assessing pollutant concentrations in wastewater and the effectiveness of their removal is crucial for developing methods to reduce the impact of new contaminants on ecosystems and human health [14]. However, there may be disagreements over the practicality and cost-effectiveness of using new treatment technology to address increasing contaminants in wastewater.

The objective of the present study is to evaluate the environmental impacts of water purification plants in Tajoura-Tripoli by conducting physical and chemical analysis, and comparing the results obtained with international specifications for industrial wastewater. Additionally, the study aims to understand the negative effects of high levels of wastewater concentration on the soil and the environment in general.

2. Materials and Methods:

Sample collection:
14 samples of wastewater resulting from purification plants located in the Tajoura area, Tripoli, Libya, were collected in January 2022 , and some measurements such as pH and electrical conductivity (EC) were directly measured.

Physicochemical Analysis:
Physicochemical analyses were performed according to APHA, AWWA and WFF [15]. And included calculating the value and concentrations of both the electrical conductivity (EC) using an electrical conductivity measuring device and calculating the concentrations of total dissolved solids (TDS) by HACH (HQ40d) device according to

what was stated in Hp Technical Assistance [16]. According to the mathematical equations based on the electrical conductivity value. pH values were estimated using a pH-meter according to the method mentioned in AOAC [17], and the concentrations of sodium Na^+ and potassium K^+ were also measured using a Flame Photometer, and chlorate Cl^- by the method of scavenging according to what was mentioned in APHA, AWWA and WFF [15], Ca^{+2} calcium, Mg^{+2} magnesium, and total hardness were measured according [18]. This is in order to identify the concentrations of pollutants in wastewater resulting from water purification plants and their negative effects on the components of the environment and the surrounding environment.

3. Results and Discussion:

All results obtained were graphically represented to facilitate their understanding and discussion. All results and data are illustrated in Table 1. Based on the data obtained, the study indicates that there are significant differences in pollutant concentrations for the tested elements due to various reasons, the most important of which are the pollutants that are released into the environment without treatment.

Table (1) shows the results of chemical analyses of the study samples:

	pH	TDs	E.C	T.H	Ca^{++}	Mg^{++}	Na^+	K^+	NO_3^-	SO_4^{--}	Cl^-	CO_3^{--}	HCO_3^-
1	*6.04 7.0	*70 1187.7	*125.1 1988.7	*17.4 865.0	161.3	110.3	106.5	0.57	6.4	500	392.3	266.7	57.7
2	*7.05 7.6	*291 543.7	*505.3 930.7	*17.3 436.7	60.0	87.7	68.4	0.53	4.8	62	143.2	60.0	488.0
3	*7.40 7.4	*316 456.0	*551.7 782.7	*17.4 353.3	80.7	41.5	63.6	0.43	3	50	165.2	93.3	392.5
4	*7.11 7.1	*1815 4325.0	*2981.7 6852.7	*17.4 2403.3	440.7	291.7	820.0	5.33	3.6	147	2383.6	56.7	620.0
5	*6.75 6.9	*6545 11286.7	*10109.7 16773.3	*17.4 5440.0	663.3	930.7	1719.0	3.33	4.7	860	6742.6	60.0	441.7
6	*7.25 7.1	*1282 2058.0	*2138.0 3376.0	*17.3 1315.0	376.0	224.7	169.9	1.33	4.6	130	2741.2	60.0	427.0
7	*6.74 6.9	*3465 6006.7	*5541.7 9353.3	*17.4 3016.7	432.0	448.0	1175.7	1.67	6.4	500	3199.2	300.0	305.0
8	*8.27 7.6	*369 439.7	*640.7 757.3	*17.4 383.3	54.7	59.7	62.6	0.43	5.1	41	80.7	90.0	248.5
9	*6.94 7.3	*1260 1564.0	*2113.0 2603.3	*17.5 883.3	231.3	72.7	162.3	0.70	5.4	140	748.2	150.0	122.0
10	*7.19 7.2	*1627 3933.3	*2690.0 6263.3	*17.4 1843.3	382.0	213.7	969.0	3.00	6.3	390	2042.5	153.3	524.5
11	*7.06 7.3	*907 920.7	*1538.3 1560.0	*17.5 441.7	64.7	66.6	128.1	0.67	4.6	140	307.0	120.0	61.0
12	*6.94 7.2	*238 286.3	*554.3 561.0	*17.6 250.0	54.7	25.7	40.2	0.27	4.2	34	61.7	30.0	61.0
13	*7.08 7.6	*307 766.0	*601.0 1462.3	*17.5 563.3	16.0	128.7	96.5	0.63	3.2	87	177.9	90.0	518.5
14	*6.76 6.8	*319 317.7	*625.3 625.3	*17.7 251.7	20.0	47.7	44.8	0.27	2.8	240	80.4	60.0	152.5

*** The Value of Source water.**

pH Values: The pH values in Table (1) for all studied samples ranged between 6.8 and 7.6. These values fall within the permissible limits for water compared to international standard specifications.

Electrical conductivity (E.C): The results in Table (1) showed that the electrical conductivity values exceeded the permissible limits. The increase in the electrical conductivity values of the source water is due to the increase in the concentration of salts in the well water, which ranged between 125.1 and 10,109.7 ms/cm. In the reject water, we notice an increase in the conductivity, which ranged between 561 and 16,773.3 ms/cm. The increase in electrical conductivity of water corresponds with an increase in the values of total dissolved solids (TDS) for all samples, and the increase is expected in wastewater after the purification process. By comparing the E.C values of source water with reject water as shown in figure (1) below:

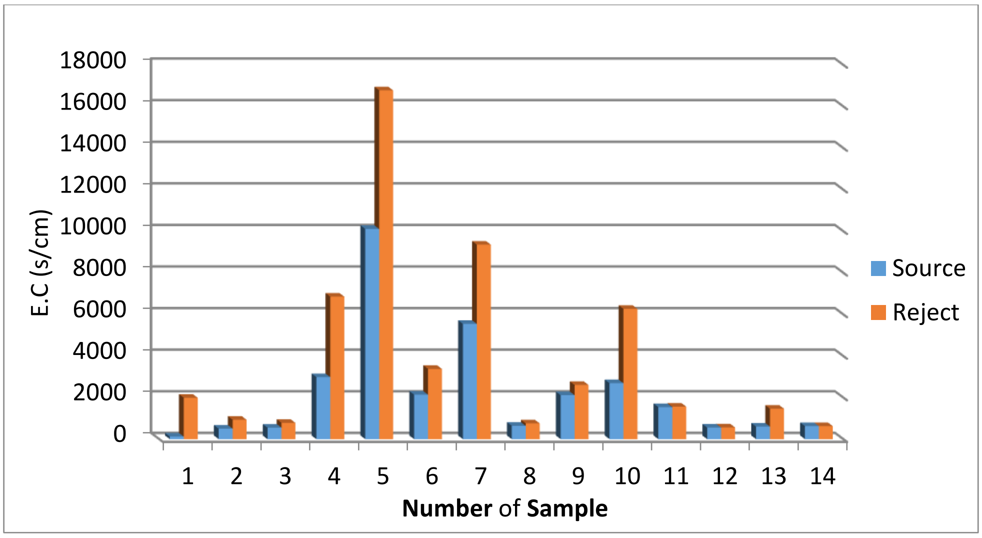

Figure (1): Comparison of (E.C) values of source and Reject water samples.

TDS: The concentration values of total dissolved salts for the source water ranged between 70-6545 mg/L, and for the reject water between 286.3-11286.7 mg/L as shown in Figure 2. The results of analyses of total dissolved salts indicate an increase in the concentration of salts in wastewater compared to well water used as a source for water purification plants. We notice from Table 1 a clear change in the concentration of total dissolved salts, as their concentration Increases as a result of the purification processes carried out by the station. This results in an increase in the concentration of total dissolved salts in the resulting wastewater, which is often disposed of directly into the soil without any treatment operations, which presents wastewater disposal methods for samples from the study area.

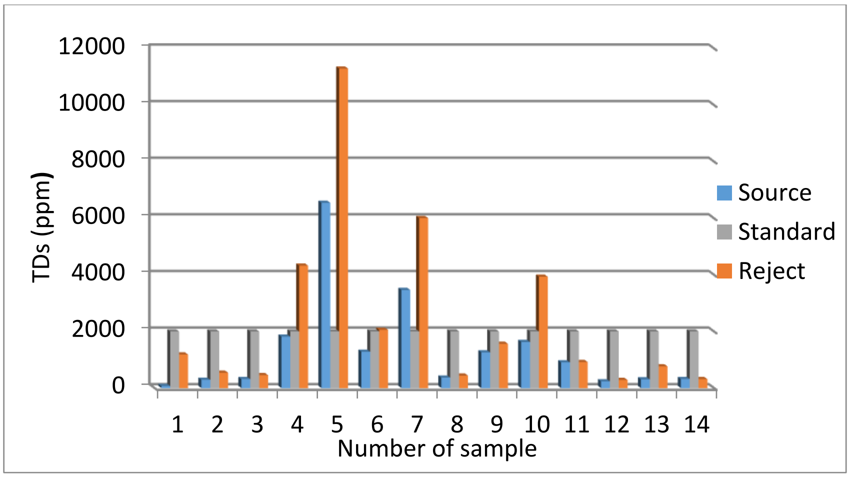

Figure (2) Comparison of the concentration of (TDS) in well water, reject water, and the standard specifications for industrial wastewater.

By comparing these values with the values recommended in the international standard specifications for industrial wastewater, it becomes clear that the values of total dissolved salts for samples (4,5, 6, and 10) have exceeded the permissible limits. This has resulted in a high increase in electrical conductivity values, which serves as evidence of an increase in salt concentration. Comparing the conductivity values to the results for total dissolved salts, it is evident that there is a significant agreement between these values. This indicates the overall high salinity of the wastewater in these stations. The presence of excessive salts in the soil can cause delayed or weak seed germination, lack of vegetative growth, specific damage to the leaves, and even plant death.

Total Hardness:

Hardness is primarily caused by dissolved calcium (Ca) and magnesium (Mg), which depend on the local geology. According to the results in Table 1, the reject water exhibited a high level of hardness in nearly all samples, as shown in Figure 3. Sample 5 had the highest value at 5440.0 mg/L, while sample 12 had the lowest value at 250.0 mg/L. It is worth noting that all samples exceeded the total hardness threshold of 200 mg/L.

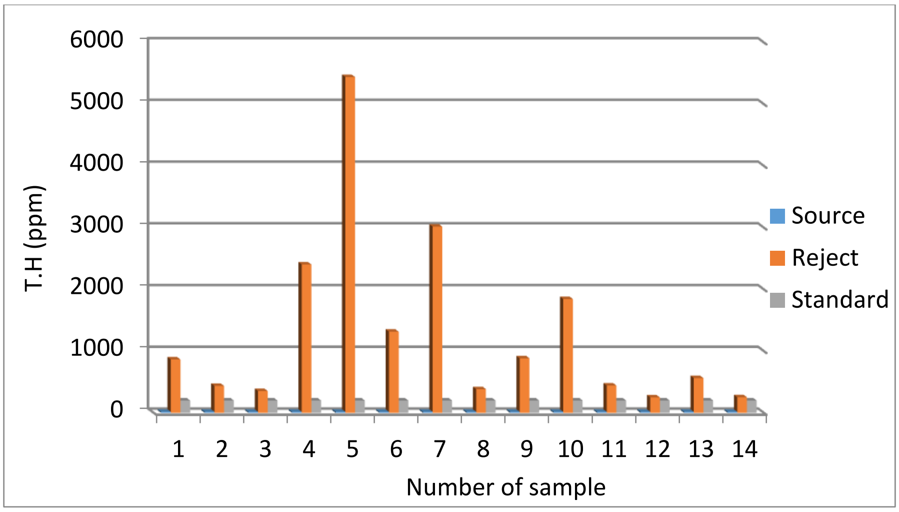

Figure (3): Comparison of (TH) values of source, Reject, reject water, and the standard specifications for industrial wastewater.

Mineral Analysis:

The analysis of the reject brine revealed a high concentration of various ions, particularly Na^{+}, Ca^{2+}, Mg^{2+}, and K^{+}. These mineral ions, derived from inorganic salts dissolved in water, are crucial for plant growth, flowering, and fruit development, all of which are vital for crop production [19]. Figure 4 illustrates the concentration of Ca^{2+}, which ranges from 16.0 to 663.3 mg/L, indicating that the reject brine serves as a reliable source of Ca^{2+}. Magnesium, found naturally in seawater/brine as magnesium oxide (MgO), is an essential mineral in plants, playing a central role in chlorophyll structure and photosynthetic activity [20]. It also participates in enzyme activities, such as maintaining reactive oxygen species balance and stabilizing structural tissues [21]. Furthermore, it is worth noting that hypomagnesemia, a deficiency of Mg^{2+} in the body, is associated with several chronic human diseases [22].

The results also indicated a significant increase in sodium ion concentration in the wastewater samples, ranging from 40.2 to 1719.0 mg/L. Carbonate rocks and minerals are the primary sources of carbonate and bicarbonate, which, when present in groundwater, elevate sodium concentration and affect plant health. When sodium, along with other positive ions, enters the soil through wastewater, it interacts with natural minerals in the soil, precipitating and leading to adverse physical conditions [23]. This alteration disrupts the natural structure of soil particles, rendering the soil compact and impermeable to water. As for potassium ion values in the wastewater samples, they ranged from 0.27 to 5.33 mg/L. From Figure 4, it is evident that the concentration of potassium in all samples did not surpass the permissible limit set by industrial wastewater standards. Although the concentration increased after purification, it remained within the internationally acceptable limits, likely due to the low initial potassium content in the source water.

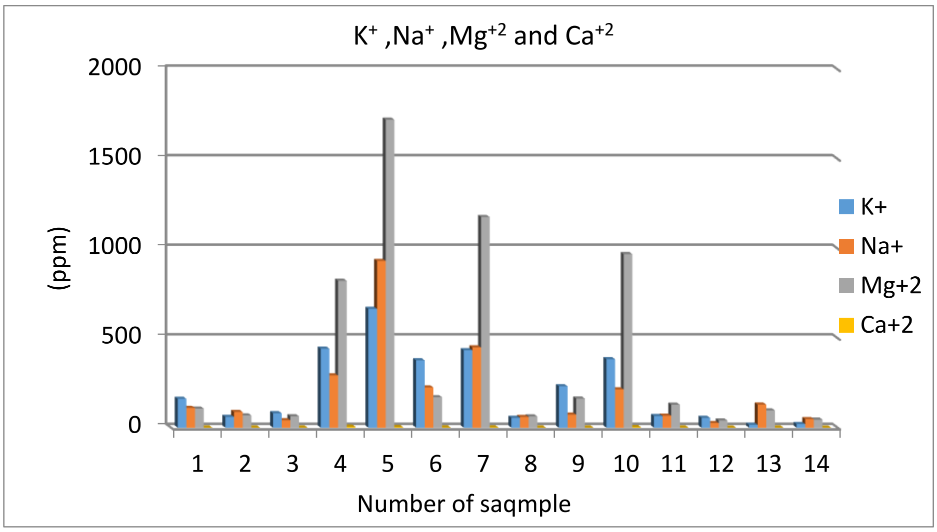

Figure (4): Ca, Mg, Na, and K Concentration in reject water.

The analysis revealed elevated levels of the (Cl^-) anion in samples (4, 5, 6, 10), surpassing the permissible limit of 350 mg/l, as depicted in figure (5). It is evident that the majority of the samples exceeded the permissible limits set for industrial wastewater. Excessive chloride concentration has adverse effects on soil quality and plant development.

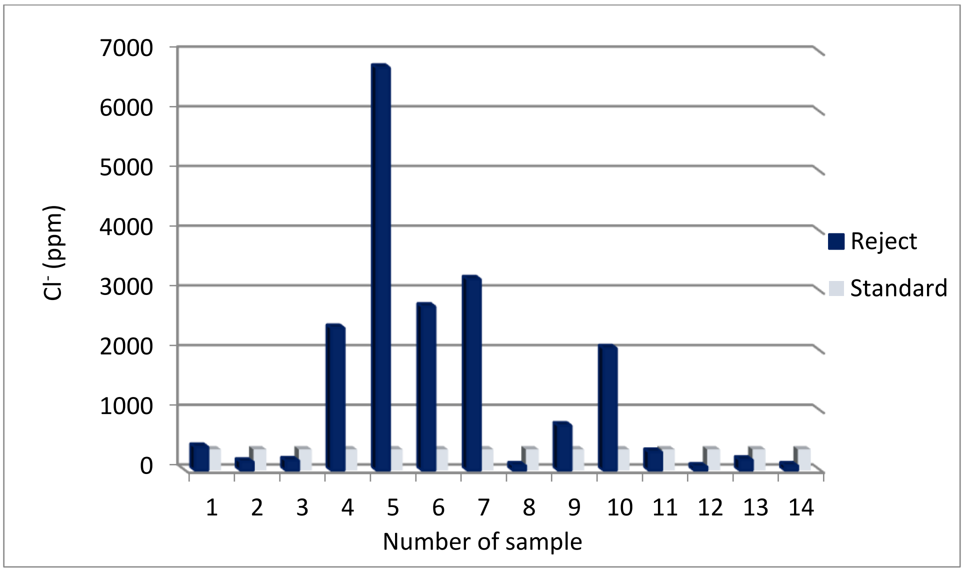

Figure (5): Comparison of Chloride ions in reject water with standard.

Figure 6 summarises the concentrations of anions, particularly showing high levels of SO_4 and low levels of NO_3. The high levels of sulphate can be attributed to the presence of sulfur-oxidising bacteria in the water. Although these bacteria may be an inconvenience, they do not pose any known health risks to humans.

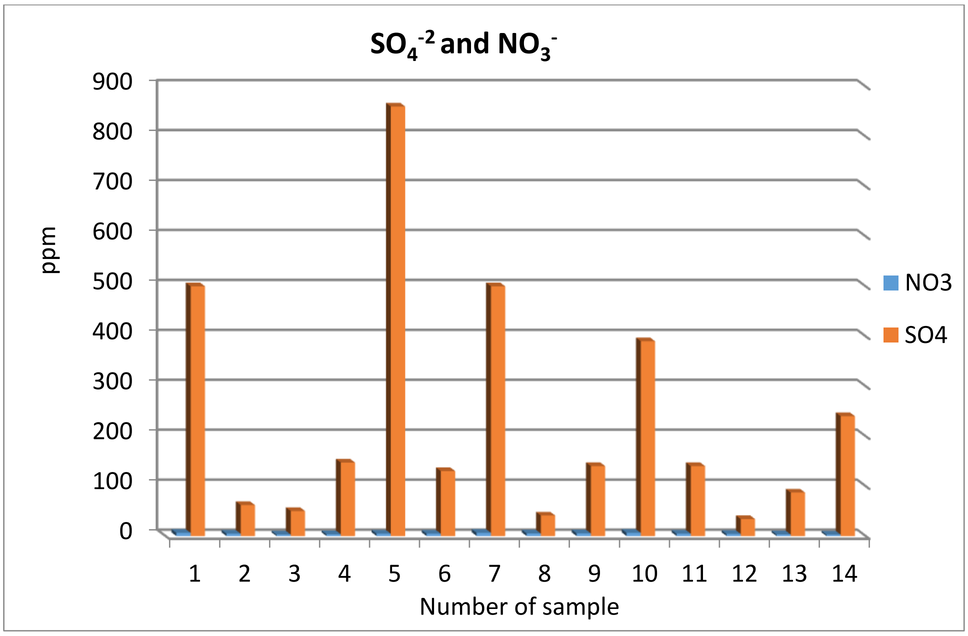

Figure (6): NO_3 and SO_4 ions concentration in reject water.

4. Conclusion:

In conclusion, the study of the concentration of pollutants in wastewater from water purification plants is crucial for assessing the effectiveness of treatment processes and addressing emerging pollutants. Continued research in this area is essential for informing policy decisions and developing sustainable solutions for water quality management. It is clear from the results of this study that it is necessary to follow up on water purification plants by the competent authorities and oblige them to add treatment units to treat the wastewater resulting from the plants before throwing it into the environment, given the harm that throwing it entails is represented by changing the physicochemical properties of the soil and the resulting negative impact on the growth of plants.

5. On behalf of all authors, the corresponding author states that there is no conflict of interest.

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