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RESEARCH ARTICLE
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Assessment of drinking water quality of some reverse osmosis (R.O) plants in Al-Diwaniya Governorate Iraq by CCME WQI

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ABSTRACT

The study conducted to use of the CCME WQI to Evaluation the quality of drinking water treated by reverse osmosis R.O. It covered the governorate of Al-Diwaniya and some of its districts (Hamza - Afak – Shamiya) water samples were collected monthly from 13 selected stations starting from August 2022 until October of the same year. Some physical, chemical and microbial factors of water were studied before treatment (tap water) and after treatment by reverse osmosis method, the results showed that the physical and chemical factors of tap water and treated water is within the Iraqi standard and the World Health Organization specification and did not exceed the permissible limits except pH, calcium and nitrates, as low results were recorded in some stations and high Total hardness permissible limit in some stations ,The results of the bacterial tests indicated the presence of bacterial contamination of the Diwaniyah River water and the absence of tap water and treated water from bacterial contamination. In this study, the water quality guide (CCME WQI) was used to evaluate water for drinking purposes, it was clear through the results that tap water is into the category (acceptable - good) and reverse osmosis treated water within the category (marginal - good) during the study period.

Keywords: *Diwaniyah City, CCME WQI, Physical, Chemical and Microbial Water Properties, Iraqi Standard Specifications, Reverse Osmosis water*

INTRODUCTION

Water is the basis of life existence and continuity without ignoring other elements, the most important of is air, and the importance of its direct comprehensiveness comes to the survival of the life of various living organisms, regardless of the proportions of their needs, human benefits from water through drinking and food and in its cleanliness directly and maintaining his health, depending on the use of water for hygiene of all kinds, provided that we do not overlook the fact that it is a source of epidemics when polluted (Al-Zahrani, 2002). human depends on water indirectly in various aspects of needs such as food and beverages, industry, manufacturing, agriculture and transportation, as well as in the generation of electric power and in many other purposes. As a result of the importance of water as one of the most important natural resources on which all social and economic activities are based, Therefore, it was believed that water resources are unlimited and inexhaustible natural resources so that they can be used without legislative or scientific controls and therefore water has taken a secondary role in development calculations (Al-Battat, 2009). but, the increasing population growth, accompanied by an increase in water consumption, especially in the last period of this century, led to the emergence of new water crises in multiple regions, which led to a clear change in concepts related to water resources and in led to a reconsideration of how to rationalize water use in all sectors and other different aspects.

The physical, chemical and biological tests of water are to assess water quality (Stambuk, 1999), the variable whose value deviates from the permissible limits according to specifications and standards is the determining factor in classifying water quality in terms of its use and pollution (Dojlido et al., 1994)

In order to assess the suitability of water for drinking purposes, there was a need to use the water quality Indicator (CCME WQI) for water assessment, this Indicator is a means of summarizing a number of water quality data resulting from repeated tests of a set of physical, chemical and biological variables and converting them into data that can be easily understood and interpreted by decision-makers, administrators and the general public (CCME, 2001). It has a single number without a unit ranging from 0 to 100 which represents a certain level of water qualit(Rosemond et al 2009; khan et al.,2003).

The CCME WQI can be used to assess water quality for drinking purposes and this depends on the nature of the standards for drinking water used to evaluate drinking water (Khan et al., 2010). Therefore, the current study aimed to study some physical, chemical and biological properties of treated and untreated water and to use the CCME WQI to know the quality of water and evaluate it for the purpose of drinking.

MATERIAL AND METHODS

The current study conducted some tap water and reverse osmosis water stations in Al-diwaniya Governorate and some of its districts (Al-Hamza - Afak - Al-Shamiya), as the samples were collected monthly by tri replicates starting from August to October 2022, where the samples were collected by plastic bottles of 1.5 liters. Several physical and chemical tests of water were carried out before and after treatment according to (APHA 2005). In the field, the pH was measured. with a pH meter, The electrical conductivity and dissolved solids with the Multi Meter Instrment as stated in (APHA, 2005), while other measurements were carried out in the laboratory that included (total alkalinity and total hardness , calcium, magnesium and chloride by the method of titration as reported in (APHA, 2005) and measurement of sodium and potassium by (flame photometer) and nitrates by (UV-Spectrophotometer) as reported in (APHA, 2005)

By pour plate method in,)Abtc (Bacterial tests included calculation of Aerobic bacterial total count Nutrient Agar as mentioned in (Abbawi and Hassan, 1990)

The Water Quality Index issued by the Canadian Council of Ministers for Water and Environment (CCME WQI) was used, which is an effective model in assessing water quality and converting it to a single number ranging between (0-100) and is characterized by flexibility in choosing measured variables to determine targets as well as high accuracy, and to calculate the value of CCME WQI for tap water and reverse osmosis water, the study dealt with the application of 13 variables to calculate the quality of drinking water according to Iraqi standard specifications Ministry of Environment, 2009

The water quality index (CCME WQI) is calculated by finding three main factors, and by calculating the three main steps, the water quality index is calculated . (CCME,2001)

$$\boldsymbol{CCME\ WQI = 100 - \frac{\sqrt{F1^2 - F2^2 - F3^2}}{1.732}}$$

F1) Scope: represents the ratio of factors whose values do not meet the criteria set for the model

(F2)Frequency: Represents the percentage of tests whose values do not meet the set criteria (failed tests).

(F3)Amplitude Represents the quantity of values of failed tests whose values do not match the established criteria

The water quality of tap water plants and reverse osmosis treated water is known by comparing it with the water guide(CCME WQI) Consisting of five categories (CCME,2017)

The statistical program SPSS version 30 was used for the purpose of analyzing the study data statistically and for the purpose of knowing the significant differences between the study coefficients, the value of the average was calculated ± the standard deviation of the studied variables and the least significant difference LSD was calculated at the level of 1%. (Daniel,2009)

RESULTS

The pH values in water sites in the study period ranged from the lowest value where it was 6.77 in station 1 in August to the highest value of 8.51 in station 13 in September for water before treatment (tap water) and the lowest value recorded 6.20 in station 8 in October and the highest value of 7.98 in station 6 in August 2022 for water after treatment (reverse osmosis water) Figure (2), While the values of dissolved solids ranged from the lowest value of 989 mg/L at Station 13 in September to the highest value of 1132 mg/L at Station 8 in September 2022, this is for water before treatment, while for water after treatmaent, the lowest value was recorded.12.4 mg/L at Station 5 in September and the highest value was 345 mg/L at Station 12 in October 2022, Figure (3). While the electrical conductivity values ranged from the lowest value was 1483 microsiemens in station 6 in September and the highest value recorded was 1710 microsiemens in station 8 in September 2022 this is for water before treatment, while for water after treatment, the lowest value was recorded at 19.2 microsemens in station 5 in September and the highest value was 518 microsemens at station 12 in October of the same year. Figure (4). While the lowest base value was 28 mg CaCo3 / L in terminal 11 in September and the highest value was 152 mg CaCo3 / L in terminal 1 in the same month 2022 This is for water before treatment ,As for water after treatment, the lowest value was recorded at 10 mg CaCo3/L in Station 11,8,6,4 in August 2022 and the highest value of 46 mg CaCo3/L at Station 3 in September of the same year, Figure (5)

The lowest value of total hardness in water before treatment was 396 mg CaCo3/L in terminal 3 in August 2022 and the highest value was 672 mg CaCo3/L in terminal 10 in September of the same year, while for water after treatment, the lowest value of hardness was recorded at 18 mg CaCo3 at terminal 8 in August 2022 and the highest value was 200 mg CaCo3/L at terminal 1 in September of the same year. Figure (6). The lowest value of calcium in pre-treatment water was recorded at 75.1 mg/L at Terminal 3 in August 2022 and the highest value at 130 mg/L at Terminal 2 in the same month of the same year.

As for the water after treatment, the lowest value of calcium 0 mg/l was recorded in station 7 in October and the highest value was 19.4 mg/l in station 12 in September 2022, Figure (7)

The lowest value of magnesium in pre-treatment water ranged from 40.99 mg/L at Station 13 (River Water) in September 2022 to the highest value of 97.6 mg/L at Station 10 in September of the same year, while for water after treatment, the lowest value of magnesium was recorded at 2.90 mg/L at Station 8 in August and the highest value was 44.89 mg/L at Station 1 in September 2022. Figure (8). The study for water before treatment recorded that the lowest value of chloride is 123.46 mg/L at Station 3 in August and the highest value was 252.47 mg/L at Station 7 October 2022.

As for water after treatment, the lowest value of chloride was recorded at 12.68 mg/L at Terminal 6 in August and the highest value was 83.49 mg/L at Terminal 1 in September 2022, Figure 2

As for nitrates, the lowest value in water before treatment was 1.917 mg / l in station 4 in August 2022 and the highest value was 8.613 mg / l in station 3 in October of the same year, as for water after treatment, the lowest value of nitrate was recorded at 0 mg / l at station 11-8-7-6-4-2 in August 2022 and the highest value was 2.917 mg / l at station 3 in October of the same year. Figure (10). In water before treatment, the lowest value of sodium was recorded at 14.10 mg/L at Station 10 in October and the highest value at 90.0 mg/L at Station 9 in October 2022, while for water after treatment, the lowest value of sodium was recorded at 4.0 mg/L at Station 7 in August and the highest value was 43.78 mg/L at Terminal 1 in September 2022. Figure (11)

While the study showed that the lowest value of potassium in the study in pre-treatment water was 3.0 mg / l in station 3 in August 2022 and the highest value was 11.8 mg / l in station 1 in the same month and year, while in water after treatment, the lowest value of potassium was recorded at 0.1 mg / l in station 7.11 in August and station 7 in October 2022 and the highest value was 4.7 in station 1 in September of the same year. Figure (12). As for the microbial results, they exceeded the permissible limit of the Iraqi standard for drinking water, as the highest values were recorded in the water before treatment, and they were (310 CFU/ml) in station 13 (river water) in October and (116 CFU/ml) in station (3 water of the water) in August 2022, and did not exceed the permissible limit of the Iraqi standard in the rest of the stations.

In the water after treatment, no bacterial contamination was recorded in the stations throughout the study period, Figure (13). As shown by the results of the CCME WQI (CCME WQI) for drinking water according to Iraqi specifications, the quality of water before treatment (tap water and river water) during the study period was recorded between (72.60 - 81.07) and falls within the category (acceptable - good) and the quality of water after treatment (reverse osmosis) was recorded between (61.08 - 92.57) and falls within the category (marginal - good) for the months of the study (CCME, 2017) Figure (1)

DISCUSSION

The current study showed a convergence in pH values at the study sites and for the three months, the pH values of water before treatment and water after treatment were within the permissible limits of the Iraqi standard, with the exception of Station 7 after treatment in October 2022, Figure

(2) recorded less than the permissible limit of the Iraqi standard.

The pH values of this study were similar to the study of (Razouki, 2010) and similar to the study (Ajeel, 2017), and the results of the statistical analysis showed significant differences between the pH results of the water before treatment among them and with the pH results of the water treated with reverse osmosis except for the 3.13 station in September and October and the pH correlation with the physical properties and chemical

The results of the current study of the values of electrical conductivity of water before treatment were within the permissible limits of the Iraqi standard, as for water after treatment, the values of electrical conductivity were less than what was mentioned in the Iraqi standard, and the explanation for this difference in the results between water before treatment and compared with water after treatment as the treatment of water by reverse osmosis led to a decrease in its concentrations in water by oxidizing negative and positive ions for salts (Eagleton, 1999)

The electrical conductivity results of this study were consistent with the study of [Mamouri, 2017; Abdel Nafie, 2011] and higher than what was recorded in my study and higher than what was recorded in the study of [Razouki, 2010; Al-Qayyim, 2017]. The results of the statistical analysis showed significant differences between the results of the electrical conductivity of the water before treatment among them and with the results of the electrical conductivity of the water treated with reverse osmosis except for station 13 in September and October and the correlation of electrical conductivity with physical and chemical properties .

The results of the dissolved solid salt values of water before treatment have exceeded the permissible limits of the Iraqi standard for drinking water and the values of dissolved solids for water after treatment within the permissible limit of the Iraqi special standard for bottled drinking water, except for station 12 in September, Figure (3).The results showed that there are significant differences between the water before treatment compared to the water treated by reverse osmosis and the reason may be comfort to technical factors related to the quality of treatment and desalting processes used in desalination plants as well as reasons related to the geological nature and salt content of the lands that embrace the water source (SDWF, 2008)

The results indicate that the total alkalinity did not exceed the limits of the Iraqi specification for drinking water for water before treatment and was less than the normal range of the Iraqi standard for water after treatment, and the results of the total alkalinity were compatible with studies [Al-Halub, 2014Al-Samarrai, 2007), while the reason for the decrease in alkalinity may be due to the high temperatures that deposition bicarbonates, which reduce their value (Jibril, 2006). The results of the statistical analysis showed significant differences between the results of the total alkalinity of water before treatment among them and with the results of the total alkalinity of water treated with reverse osmosis except for station 13 in the months of the study and the correlation of the total alkalinity with physical and chemical properties, and most of the previous studies on the different Iraqi water bodies agree that their water is of weak base due to the abundance of carbonate and bicarbonate ions (Al-Saadi et al, 2000)

The results of the study showed that the total hardness values of water before treatment exceeded the permissible limits of the Iraqi standard for drinking water, while the results of the total hardness of water after treatment were within the permissible limits of the Iraqi standard for bottled drinking water and were similar to the results of study [Al-Hadrawy,2007; Al-Amiri et al.,2013]

Water hardness has a main cause in development and disorders of the nervous system, as high neurodegenerative diseases have been found in areas with high levels of calcium and magnesium as an association between concentrations of these elements and the occurrence of diseases was obtained from a series of Wilcoxon tests (Richer et al., 2017). The results also showed significant differences between the hardness results of water before treatment compared to the results of reverse osmosis treated water, and this difference may be explained by reasons related to the geological structure and type of salts prevailing in the soil containing the water source used for production (Chukwu, 2008), as well as reasons related to the concentration of industrial and domestic pollutants that are released to surface water sources (Gupta et al. 2009)

The current study recorded that the results of calcium were within the Iraqi standard for drinking water and did not exceed the permissible limit in water before treatment, either the results of calcium in water after treatment or bottled did not exceed the permissible limit of the Iraqi specification and recorded low values in some stations, and station 7 in October 2022 was completely free of calcium, Figure (7), The reason for the low concentration of calcium in water after treatment may be due to technical factors related to the quality of treatment and desalting processes used in desalination plants, and its decrease or lack of access to it in sufficient quantity may affect human health, causing osteoporosis (American Institute of Health) (NIH, 2021), as well as its importance in bone and dental formation, blood clotting, and the functioning of the nervous system (Abed, 2007)

The calcium results of this study were consistent with the results of studies [Alwan,2017; Ali,2021]. The results of the statistical analysis showed significant differences between the calcium results of the water before treatment among themselves and with the results of the calcium figure of the water treated with reverse osmosis except for the 13th plant in August and the correlation ofcalcium with the physical and chemical properties.

While the results of the study showed that the magnesium values did not exceed the permissible limits in the Iraqi standard for drinking water in water before treatment, either in water after treatment or bottled, the magnesium results had exceeded the permissible limit of the Iraqi standard, and magnesium values were less than calcium values in the study The reason may be due to the chemical properties of the soil and the geographical data of the water source, and this is what agreed with (Toma, 2009) and (Tahir, 2010). Thus, a moderate level of magnesium is important in preventing geriatric diseases and oxidative stress (Barbagallo et al., 2021). The magnesium results were consistent with the results of the study (Al-Amiri et al., 2013) and an approach to the study (Al-Khatib, 2007). The results of the statistical analysis showed significant differences between the magnesium results of the water before treatment among themselves and with the magnesium results of the water treated with reverse osmosis except for the 13 plant in September and the association of magnesium with the physical and chemical properties.. While the

The present study showed that the results of chloride were within the normal range of the Iraqi standard and did not exceed the permissible limit in water before treatment and water treated with reverse osmosis, and the results were similar to the results of studies [Al-Amiri et al., 2013; Razouki, 2010; Abdul-Abbas, 2015]; [Al-Hadrawy,2007]. The results of the statistical analysis showed significant differences between the chloride results of the water before treatment among them and the chloride results of the water treated with reverse osmosis with the exception of the 13 plant in September and October and the correlation of chloride with physical and chemical properties..

The study showed that the results of nitrates were within the permissible limits of the Iraqi specification for drinking water before treatment and water after treatment or bottled, and there were significant differences between nitrates in water before treatment compared to water after treatment, and this difference may be due to the origins of water, its survival period and climatic conditions (Alam et al., 2017), and because nitrate has a major role in water damage and pollution, which is one of the dangerous and toxic ions, as well as its impact on human health, as scientists and doctors agreed. on the toxic effectiveness of nitrates for humans and animals and causes many diseases, the most important of which are childhood cyanosis and cancer diseases (Wagh et al., 2020). The nitrate results of this study agreed with the results of the study (Al-Amiri et al., 2013).There was also an association between nitrates with physical and chemical properties in the study.

The results of the current study recorded that the sodium values were within the permissible limits of the Iraqi standard for drinking water for water before treatment, while the sodium values in the water after treatment or bottled were less than the limits recommended by the US Environmental Protection Agency, which is (20 mg / liter) (Al-Omran et al., 2013), and the results of the sodium of this study coincided with the results of the study (Al-Saffawi, 2018), studies have also shown that sodium is important in regulating the osmotic pressure of the body's cells and works to maintain the acidity and alkalinity balance and has an auxiliary role in muscle contraction (Al-Zawali, 2019), and it has been shown that the risk of cardiovascular disease and high blood pressure is associated with high concentrations of sodium (Al Aamri & Ali, 2017). The results of the statistical analysis showed significant differences between the sodium results of the water before treatment among them and the sodium results of the water treated with reverse osmosis except for the 13 plant in the months of the study and the association of sodium with physical and chemical properties.

The study showed that the potassium results of water before treatment were within the Iraqi specification for drinking water and did not exceed the permissible limits, while the potassium content was very low in the water after treatment or bottled and this decrease has a negative impact and may cause health problems, as it may cause problems and risk to people with diabetes, high blood pressure, heart and kidney disease through the treatment of water based on potassium chloride, as the exchange of ions occurs between potassium and magnesium. and calcium thus negatively affects them (WHO, 2011), and the potassium results of this study are consistent with the study (Ali, 2021.(

The results of the statistical analysis showed significant differences between the potassium results of the water before treatment among themselves and the potassium results of the water treated with reverse osmosis, with the exception of the 13 plant in the months of the study and the association of potassium with the physical and chemical properties.

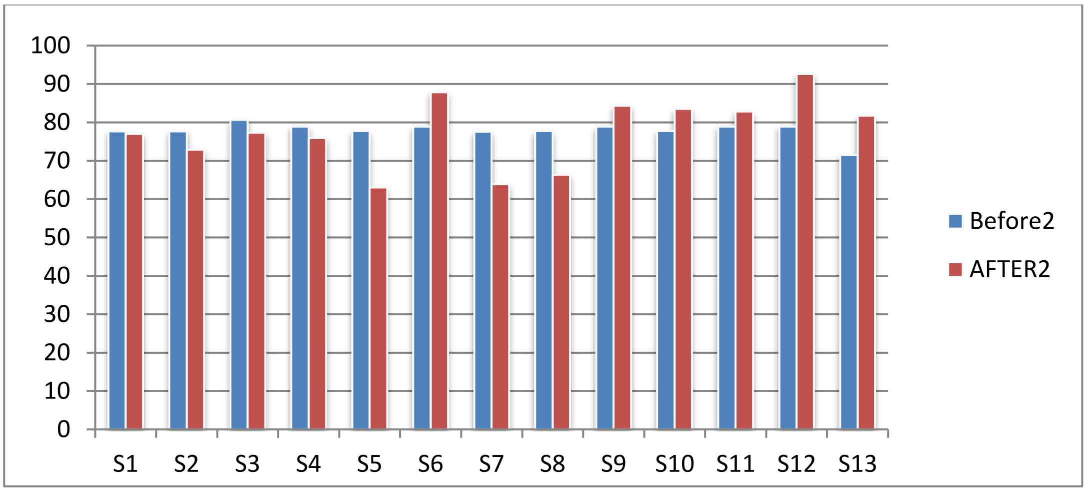
The microbial results in the current study recorded the presence of bacterial contamination in the water before treatment (river water) and it exceeded the permissible microbial limits in the Iraqi standard for drinking water, station 13 figure (13), while tap water (treated river water) recorded bacterial contamination and exceeded the permissible limit of the Iraqi specification in station 3 in August 2022, figure (13), and this pollution may be attributed to the daily activities of humans, which include household waste and waste from hospitals, schools and shops that mix with water Sewerage The remnants of these decaying wastes directly or indirectly leak into the liquefaction pipes, causing pollution of these waters (Abdul Razzaq, 2017),As well as the appropriate temperature during the study period and the abundant quantities of organic and inorganic substances resulting from the dumping of sewage waste in the river in addition to the low water level, which helps to increase the growth and activity of microorganisms in the water (Fukami et al., 1983). In addition to the types of pollutants and agricultural residues from the lands surrounding the river and adjacent to it that flow into it, as well as the slow flow speed, and the pollutants released into the river water from sewage and agricultural and domestic pollutants have a significant negative impact on the ability of the river to self-purify from the excreta area, even for a distance (Al-Ghanmi, 2015; WHO,2011)

As for reverse osmosis water, the study did not record any bacterial contamination in the water of the examined stations throughout the study period and was within the Iraqi specifications for bottled drinking water and did not exceed the permissible limits, and the quality of the water and its freedom from bacterial contamination may be attributed to sterilization processes as the ozone has high efficiency in the sterilization process and the elimination of bacteria (Tawfiq et al., 2015), These results were consistent with the study of [Abdulabbas, 2015; Al-Qayyim, 2015; Al-Yaqoubi, 2022]. The results of the statistical analysis showed significant differences between the results of the bacteria of the water before treatment with the results of the bacteria of the water treated with reverse osmosis in the months of the study.

As shown by the results of the current study, the water quality guide for drinking purposes (the

CCME WQI) for water before treatment ranged between the two categories (acceptable - good) throughout the study period, either the water quality guide (CCME WQI) for water after treatment or bottled falls within the two categories (marginal - good) for drinking purposes, it is clear from the results of the water quality guide for drinking purposes that the values of the index were an indicator that all the water examined during the study was directly drinkable This may be attributed to the values of physical and chemical factors. Bacteria were within the permissible limits except for some factors (pH, total hardness , calcium and nitrates) recorded a decrease or a slight increase from the normal permissible limit. The study also recorded significant changes between pre-treatment water compared to reverse osmosis treated water in most stations in the three months of the study, with the exception of station (11-12) in September 2022 and station (12) in October of the same year at a significant level of $P < 0.01$.

August



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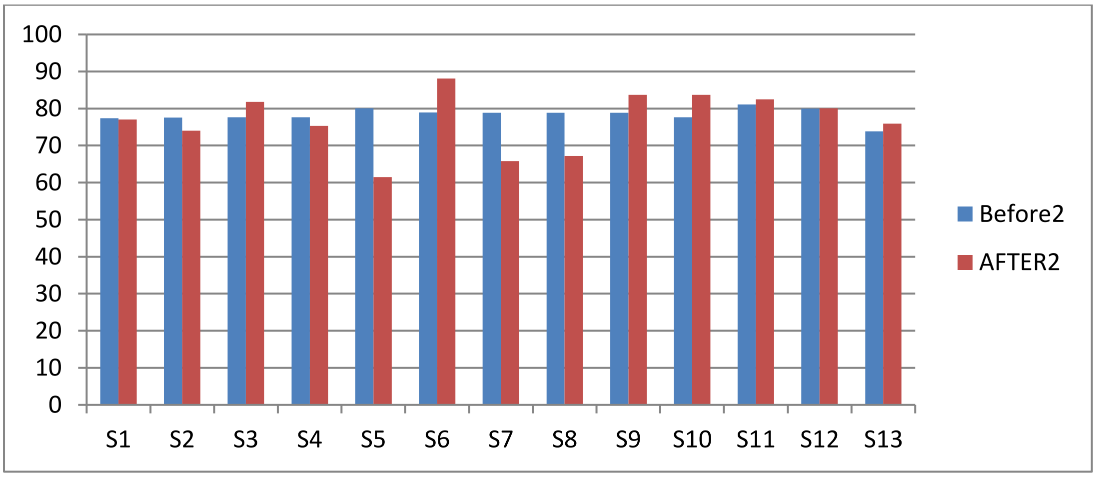

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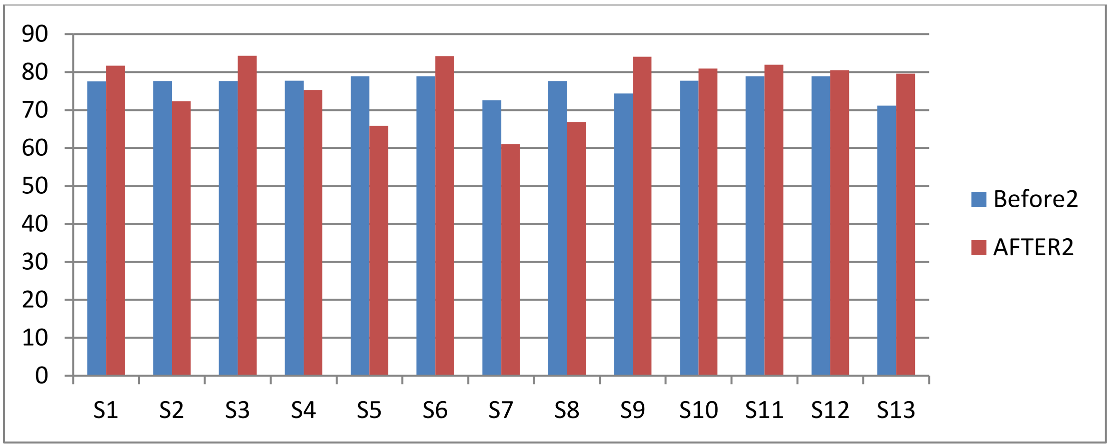
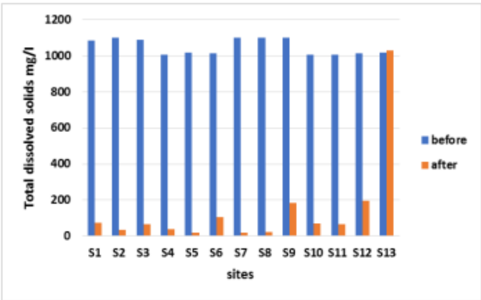


FIGURE 1: Canadian Water Quality Guide CCME WQI for Drinking Water Plants

August



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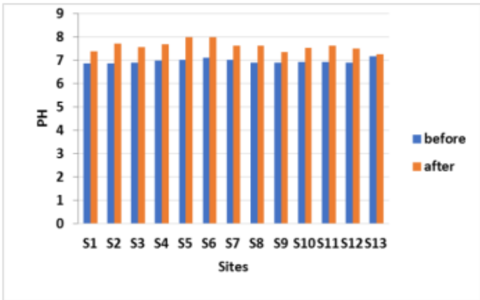

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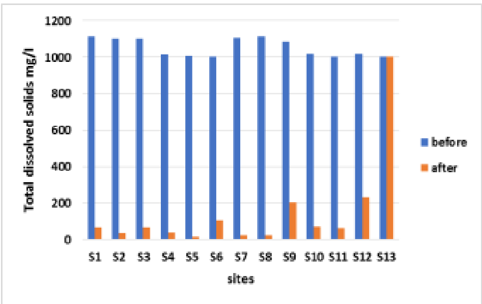

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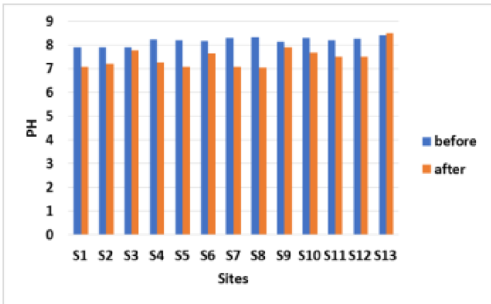

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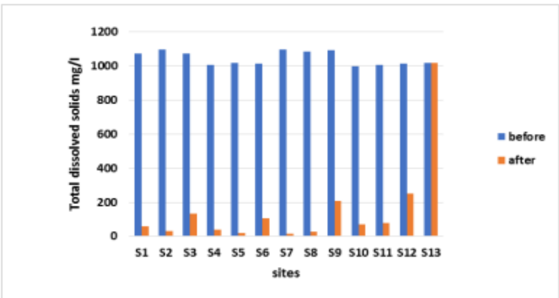

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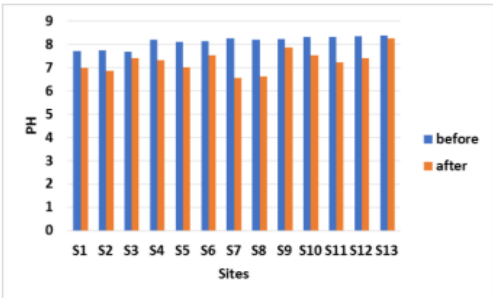


FIGURE 2: pH rates

FIGURE 3: Total Dissolved Solids Rates

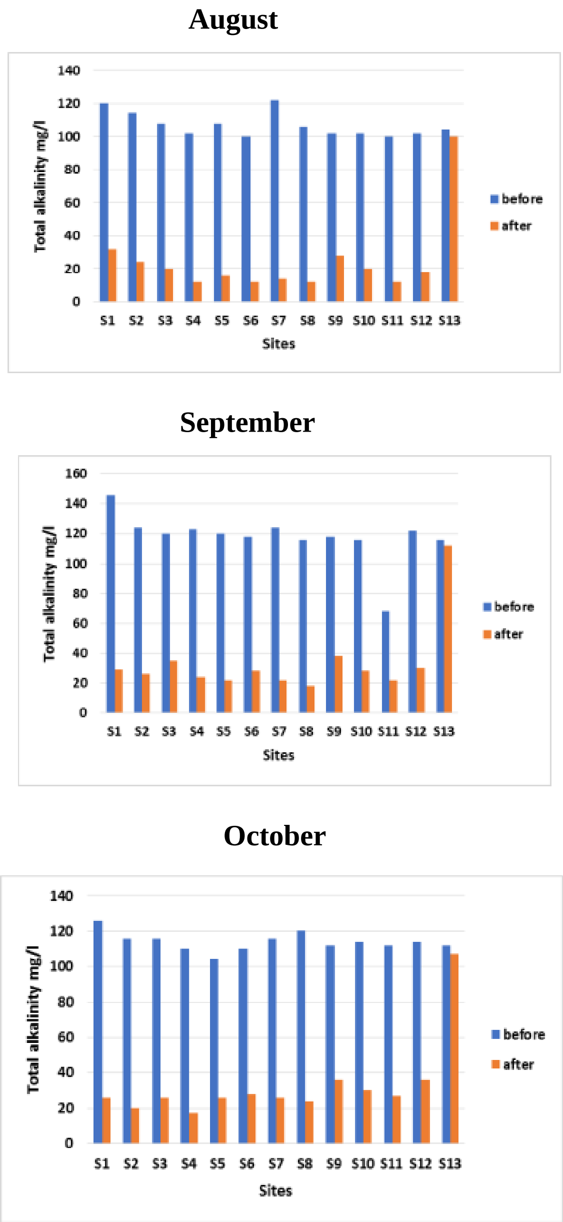


FIGURE 4: Electrical conductivity rates

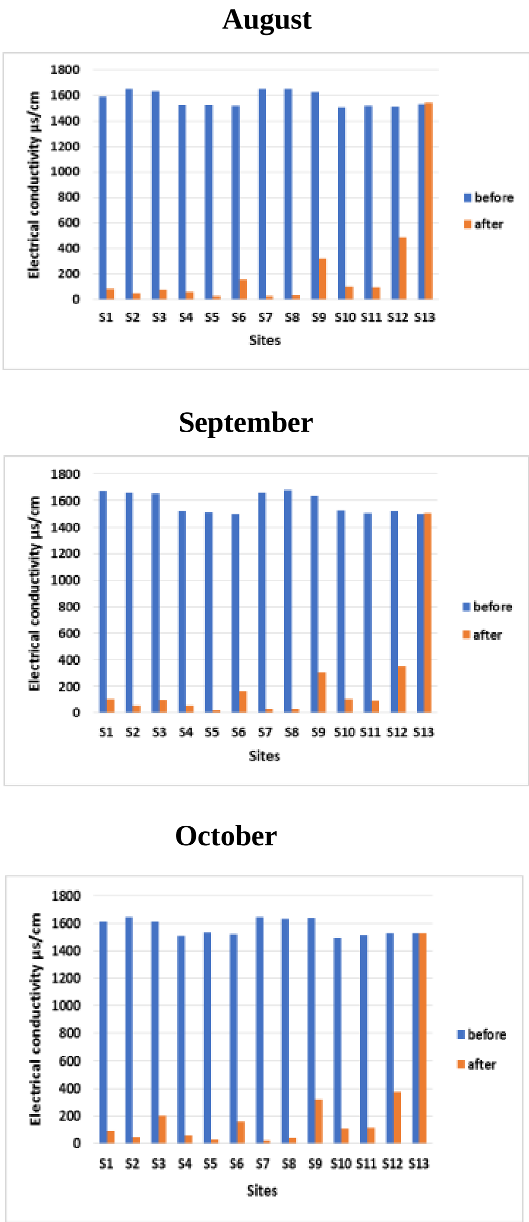
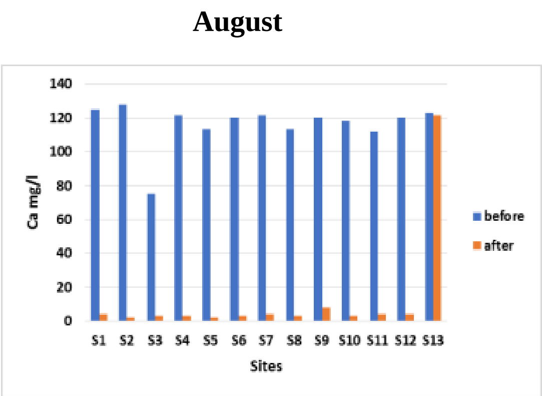
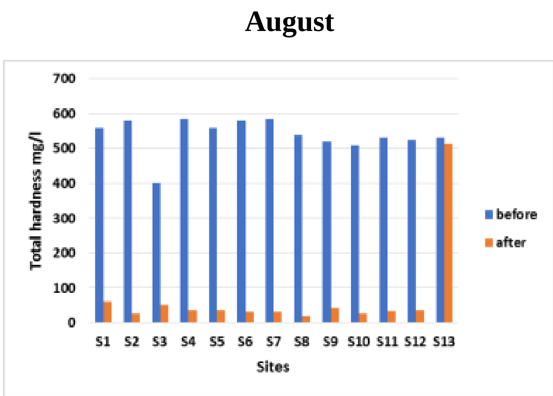


FIGURE 5: Total alkalinity rates





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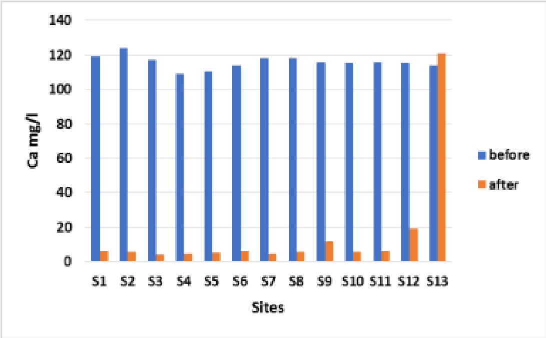

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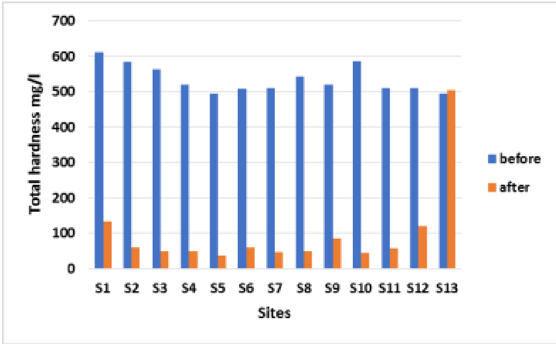

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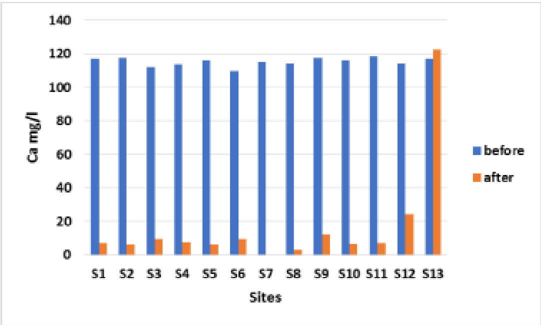

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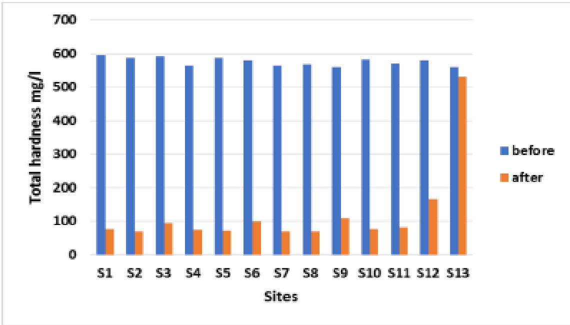
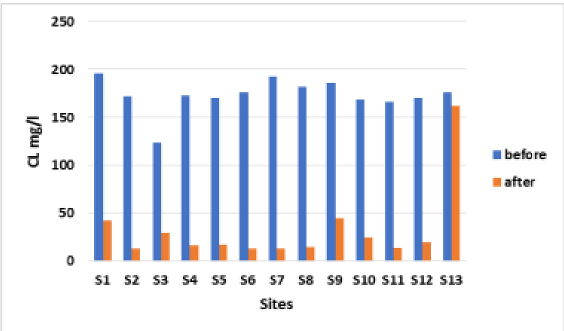


FIGURE 6: Rates of total hardness values

FIGURE 7: Rates of calcium values

August



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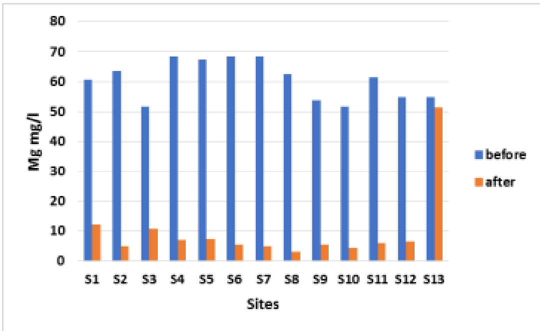

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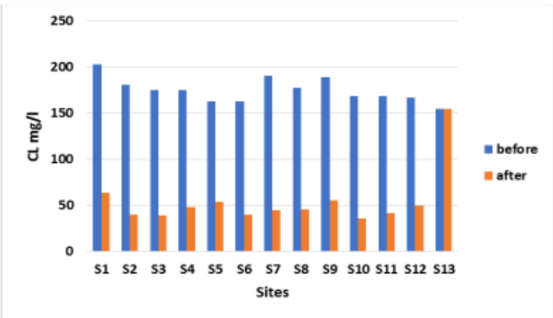

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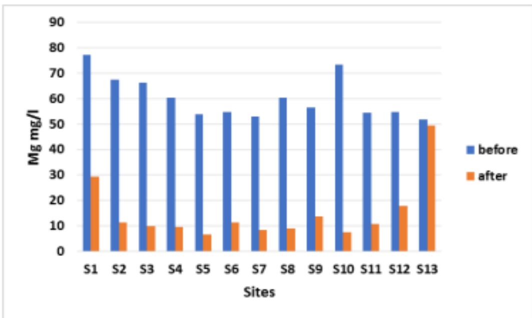


October

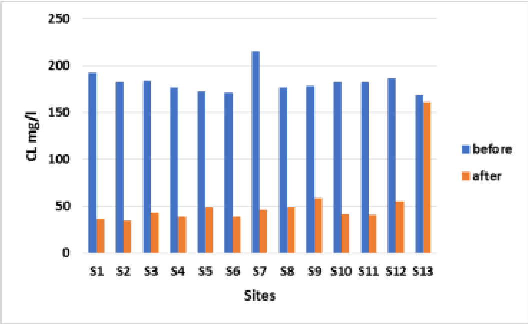


FIGURE 8: Average Magnesium Value

October

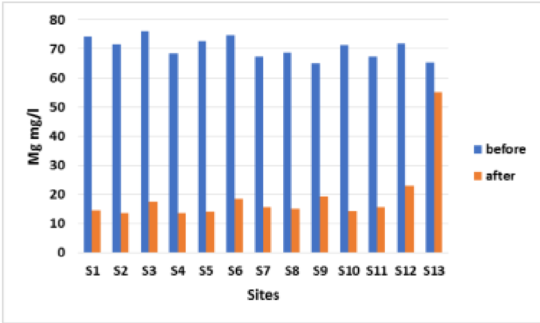
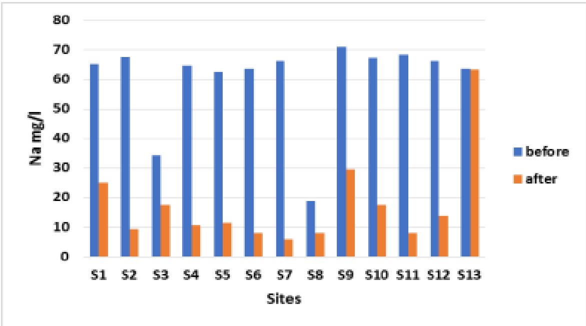
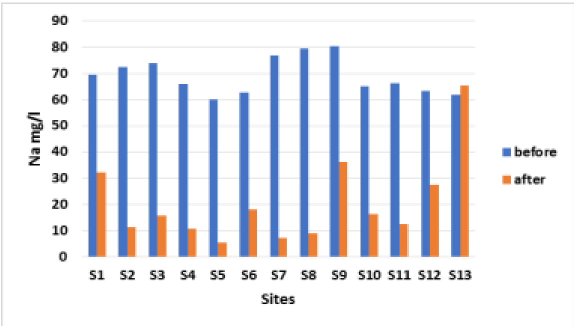


FIGURE 9: Rates of chloride values

August



September



October

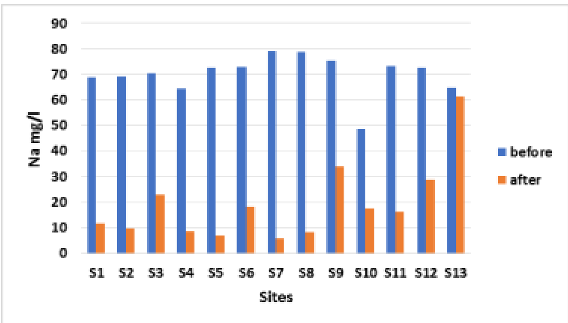
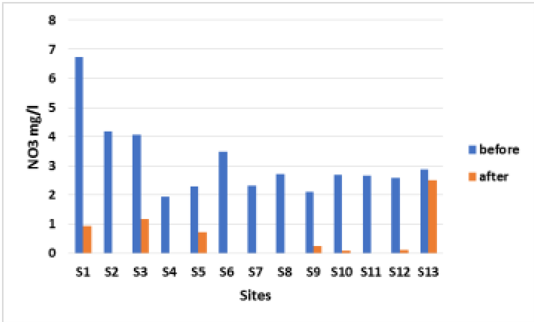
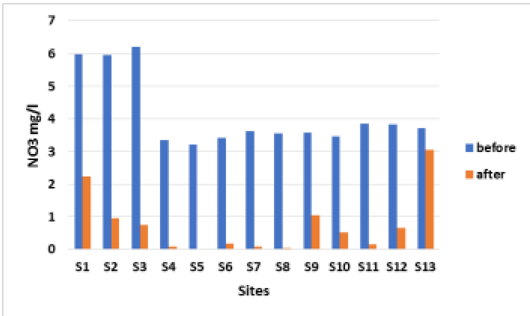


FIGURE 10: rates of Nitrate Values

August



September



October

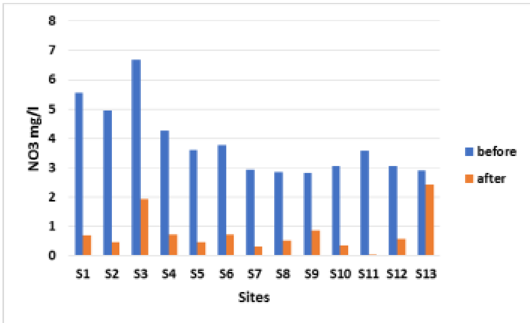
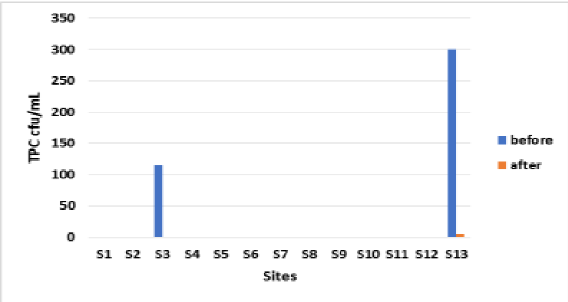
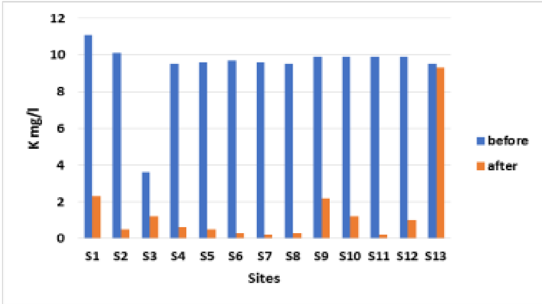


FIGURE 11: Rates of sodium values

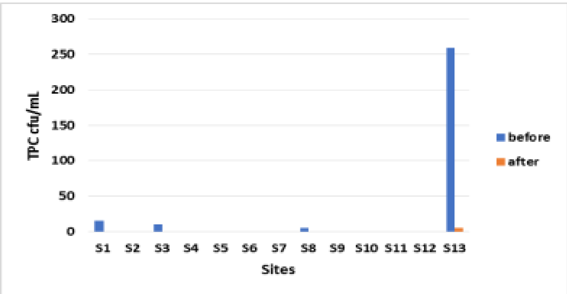
August



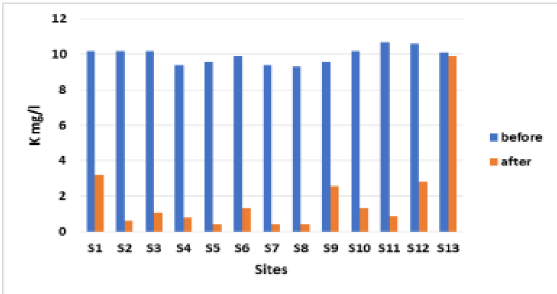
August



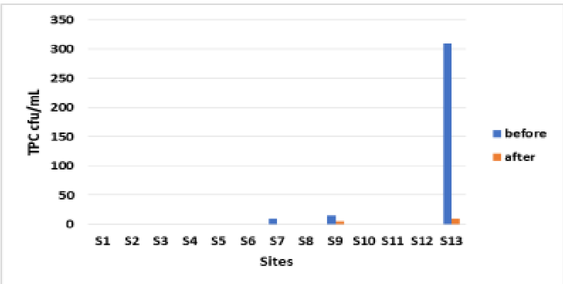
September



September



October



October

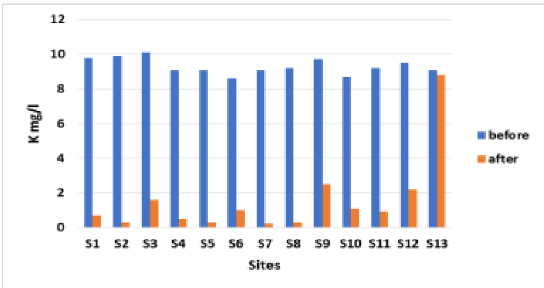


FIGURE 12: Rates of potassium values

FIGURE 13: Rates of the total number of bacteria

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