Journal of Energy Research and Environmental Technology (JERET)
p-ISSN: 2394-1561; e-ISSN: 2394-157X; Volume 6, Issue 1; January-March, 2019, pp. 49-55

http://www.krishisanskriti.org/Publication.html

Quality Assessment of Drinking Water from Groundwater System in Kalindi College

Divya Verma[1], Aishwarya Dharan*[2], Bhawna Bangari*[3], Charu*[4] and Vandana Sharma*[5]

[1,2,3,4,5]Kalindi College, University of Delhi
E-mail: [1]divyarohilla@yahoo.co.in, [2]aishwaryadharan@gmail.com, [3]bangari043@gmail.com, [4]charujuneja4500@gmail.com, [5]vandana.sh1098@gmail.com

Abstract—*With rapid development in the past few years, there has been rise in pollution levels especially in water. This creates a necessity to assess the drinking water quality on timely basis. Delhi, the capital city of India, with an area of 1483 sq.km., and a population density of 9340 persons/ sq.km., has the highest water demand which makes it all the more important to regularly assess quality of drinking water. Drinking contaminated water causes 80% of human diseases. The quality assessment of Groundwater sample was done to ascertain the pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Hardness (TH), Total Alkalinity (TA), Free Carbon Dioxide, Dissolved Oxygen (DO), and Electrical Conductivity (EC) of water, which was compared with World Health Organisation (WHO) standards, to determine the acceptability of the available drinking water. The Groundwater (Inlet) samples were collected from the college RO plant. The analysis was done. The TDS and EC of Groundwater crossed the WHO permissible limits. The Water Quality Index (WQI) was used to determine the water quality of the groundwater sample. The values of 6 parameters, pH, TDS, TH, Chloride, EC, and TA were taken to determine the WQI of the groundwater sample. High WQI of groundwater indicated very poor quality thereby, not suitable for drinking. This is due to high concentration of ions and solutes in water samples.*

Introduction

Water is the most abundantly available natural resource on Earth and the source of development of life. It is also the basic need of humans, plants and animals for survival. A human can survive up to 4 days without water. Of the 70% water that is available on Earth, only 2.5% of it is freshwater [1].

These days environmental pollution is a global concern which is also affecting the quality of drinking water. The rapid rise of Industrial sector and thereby the increase of toxic effluents released from industries not only affect marine life in water bodies but also seep down the Earth and affect the quality of groundwater. This groundwater when absorbed by crops along with pesticidetreatment thus becomes a part of the food chain. This groundwater is also drunk by people and if not treated properly can cause diseases. Human diseases like Diarrhoea, Cholera, Typhoid, Dysentery and Hepatitis are caused due to lack of availability of clean drinking water according to World Health Organisation (WHO) reports. The capital city Delhi itself has a water demand of 3600 million litres per day- which is the highest than any other city in the country. So the conservation and availability of clean drinking water is a major necessity in the current times.

To cater the need of safe drinking water of more than 4000 students and around 350 employees, an RO system had recently been installed on 5th June 2017 in the campus of Kalindi College.

In the academic year of 2017-2018, a team of four students analysed the data on the water quality of the RO plant. Three samples of RO plant i.e. the Inlet (Ground Water) **(Fig. 1A)**, Outlet (Purified Water) **(Fig. 1B)** and the Wastewater **(Fig. 1C)** of 5 litres each were collected. The samples were subjected to the following tests:

Physical parameter:

- pH
- Electrical Conductivity (E.C.)
- Total dissolved solids (TDS)
- Total Suspended Solids (TSS)
- Free CO_2

Chemical parameter:

- Alkalinity
- Dissolved oxygen
- Hardness
- Chloride

These parameters were taken and compared with international standards for drinking water quality.

Reverse Osmosis (RO) is a technique to separate dissolved/undissolved solids from water. It is an effective and economic method of desalinating water. It can also be applied for desalinating sea water, ground water and for purifying water for lab and industrial use.

Osmosis is natural method of water movement from low concentration such as freshwater to high concentration of solution such as seawater, through a semipermeable membrane. The membrane is water permeable and allows few ions to pass through as well. This process goes on till an osmotic equilibrium has reached. In Reverse Osmosis, the pressure exceeds beyond the osmotic pressure which forces water from higher concentration to lower concentration. This is achieved by increasing pressure on the high concentrated solution side. The RO technique involves the feed water (inlet) which can be groundwater, seawater or any type of unfiltered water, to pass through spirally-bound layers of RO membrane.In order for the RO membrane not to get clogged by solute particles of the highly concentrated inlet, the feed water before passing through the RO membrane, is filtered. This is achieved by using multimedia filters which are tanks or vessels containing a series of layered granular materials. These materials can be Anthracite, Garnet, Sand, Pebbles, and/or Gravel which are assembled in layers. The filters remove sand, twigs and other particles from the inlet water. In some cases other types of membrane like Ultrafiltration and Microfiltration membranes are used instead of multimedia filters to pre-treat the unfiltered water. After pre-treatment, the inlet water travels to the cartridge filters which act as second stage of filtration.

Cartridgeare made of a yarn-like synthetic material that is wound into cartridges. These remove even smaller solid particles from the inlet water such as fine sand and clay, before the inlet water proceeds to the RO membranes. As the inlet water travels through the pipelines, high pressure pumps attached to the pipelines increase the pressure of flow of inlet water upto 1000 PSI **(Fig. 2).** The pressure needs to be sufficiently high to overcome the naturally occurring osmotic pressure and force water from high concentrated side through the RO membranes to the freshwater side. The RO membrane is a number of sealed envelopes connected at their open ends to a core tube. It consists of a Thin-Film Composite (TFC) membrane flat sheet which has three layers: Polyester Fabric support base, a microporous polysulfone layer and a 0.2 micron thick polyamide layer. The polysulfone layer strengthens the thin Polyamide layer. The Polyamide layer removes nutrients, chemicals, bacteria and viruses from water. The membrane flat sheet is folded and a feed channel spacer is inserted in between. This creates turbulence and space between the membrane sheets for the feed water. A sheet of permeate spacer is added to the membrane sheets and feed channel spacer, which enables the final recycled water product or permeate to flow evenly across the entire membrane surface even under high pressure. The back of the membrane is completely sealed to the edges of permeate spacer. The membrane sheets are glued along each of the three exposed sides and rolled around the core tube. Feed water is forced through Feed channel spacer and into the barrier layer of the membrane. Water passes through the membrane surface into the permeate channels. It flows in spiral direction and collects in the core tube.

Fig. 1 Reservoirs: A – Inlet tank supplying groundwater to RO plant; B – Outlet containing purified water from RO plant; C – Wastewater storing tank of RO plant; D – Solar Panel

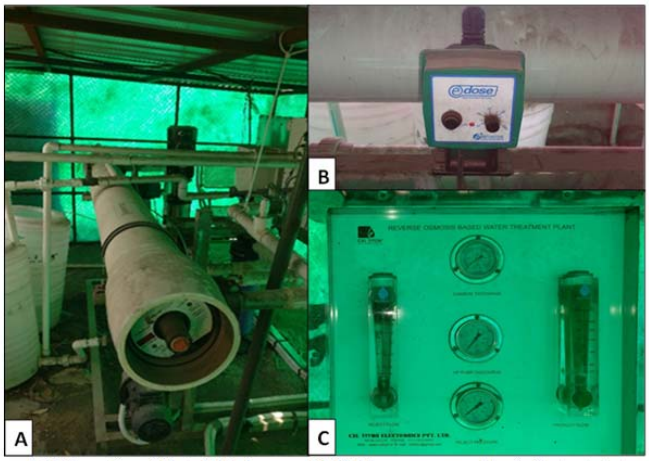


Fig. 2: Reverse Osmosis Plant: A- Membrane vessel, B- High Pressure pump regulator, C– Treatment plant regulator

This water is the final recycled water product or permeate also called the Outlet water which is suitable for drinking. The RO membranes are enclosed in a fiberglass shell. The membranes are connected end-to-end and are housed in vessels that are built to withstand pressures upto 1200 PSI. There are six to seven spiral-wound RO membranes in one pressure vessel. Once the end adapter is connected to the last membrane and the pressure vessel is sealed, feed water can be introduced.

Feed water is pumped at high pressure into the vessel as it travels, small molecules like water pass through the membrane while the larger particles such as salt, bacteria and viruses, do not. The final recycled water is collected from the end of the RO membranes. The concentrate or the wastewater from that vessel flows to another stage, producing more recycled water. We measure the various aspects of water such as the pH for determining acidity and alkalinity. High values of alkalinity indicate presence of carbonate (CO_3^{2-}), bicarbonate (HCO_3^-) and hydroxide (OH^-) ions in water body indicating good water quality. For drinking water, amount of alkalinity should in range of 200mg/lit according to WHO Standards. Drinking high alkaline water can disrupt body's pH levels and cause metabolic alkalosis which may cause nausea, vomiting, muscle twitching, tingling in face, eyes, hands and feet. We measure the Electrical conductivity (EC) for dissolved ionic substance in water. EC for drinking water should be upto 250 µS/cm according to WHO standards. Water with hardness beyond considered 200mg/lit can cause scale deposition in distribution system and a total hardness of 500mg/lit is harmful to human health. Chloride is majorly found in different concentrations. Chloride concentration should be upto 250mg/lit for drinking water. Chloride concentration more than 250mg/lit will give salty taste to water. Value of Total dissolved solids (TDS) can determine the solids dissolved in water. TDS of water between 500 ppm is safe for drinking according to WHO Standards. Drinking water should have high Dissolved Oxygen (DO) for good taste. Biological impurities, high temperature, substances such as Hydrogen sulphide reduce DO value. DO for drinking water should be in range of 6-8mg/lit in accordance with WHO standards. Total Suspended Solids (TSS) are solids in water that is trapped by a filter. TSS includes decaying plant parts, sand, silt animal matter and industrial wastes. High TSS can create problems in the sewage system and marine life. TSS for drinking water should be around 500mg/lit. Any fluctuation in any of the parameters above or below the given standards can affect human health. Therefore monitoring the water management system is necessary for continuous supply of safe drinking water. Water quality assessment helps in identification of any contamination and check the quality of water.

Materials and Minerals

Study Area

Kalindi College is a women's college located in East Patel Nagar. It has a team of 161 highly qualified, teaching faculty and an 86 membered administrative, technical and support staff. It has the strength of 4291 regular students and more than 1402 non collegiate students and about 3000 students are enrolled under Open Learning Centre. It spreads over an area of over 36,222 sq. ft. which makes it necessary to supply portable drinking water. The available source of water to meet the requirements is taken from underground water bed. This water is processed for purification by the Reverse Osmosis (RO) plant, the RO plant was installed on 5th June, 2017. It was manufactured by CXL TITON Electronics Pvt. Ltd., Model No. 80-300. The RO membrane vessel is by PENTAIR Codeline Ecoline 8 inch series. The RO plant is powered by solar energy **(Fig. 1D)**. The Solar Panels are manufactured by HERO Solar Energy Pvt. Ltd. The RO plant was last serviced on 30th May 2018.

Sampling preservation and Analysis

Three samples were collected from 3 sampling sites in 5 litre plastic cans. The samples were refrigerated and stored at temperature 4°C and used for analysis within 24 hrs. The water samples were analysed for various physiochemical parameters such as pH, EC, TDS, TSS, Total Alkalinity, Total Hardness, free CO_2, Chloride and Dissolved Oxygen. EC was measured using digital conductivity meter. TDS was measured using a portable TDS meter. TSS was measured by wetting, drying and weighing clean filter paper washed with water sample. Rest of the tests were performed by Titration method. All the various apparatus used were washed with distilled water.

Water Quality Index

Water Quality Index (WQI) is defined as a grading of different water quality parameters to determine the overall quality of water. The World Health Organisation (WHO) standard specified for drinking water was used for the WQI calculation. The WQI is calculated in three steps.

First, the six parameters (pH, EC, TDS, Total Hardness, Chloride, EC, and Total Alkalinity) were assigned a weight (wi) according to its importance in the overall drinking water quality [2]. Second, the relative weight (Wi) of the chemical parameter was calculated using the following equation:

$$W_i = \frac{wi}{\sum_{i=1}^{n} wi}$$

Where, Wi denotes the relative weight; wi is the weight of each parameter, and n is the number of parameters taken.

Third, the rating scale (qi) for each chemical parameter is calculated by dividing concentration of given chemical sample (Ci) by standards of each parameter given by WHO (Si), which is multiplied by 100.

$$q_i = \left(\frac{Ci}{Si}\right) \times 100$$

For determining the WQI, the sub index (SI) is calculated for each chemical parameter. The summation of SI gives the WQI.

$$SI_i = W_i \times q_i$$

$$WQI = \Sigma\, SI_{i\text{-}n}$$

Where, SIi is the sub index of ith parameter; Wi is the relative weight of ith parameter; qi is the rating scale for each parameter, and n is the number of parameters.

Table 1. Water Quality Index of samples

Sample	WQI
Inlet	182.97
Outlet	43.56
Wastewater	235.12

Results

Inlet Water

The pH is an indicator of acidity or alkalinity of water. In the study, pH of the inlet water sample did not exceed the WHO standard range of 6.5-8.5 (**Graph 1**). The Electrical Conductivity (EC) value indicates the presence of ions in given sample. The EC value of inlet is 786 µS/cm which exceeds the WHO permissible limit of 300 µS/cm **(Graph 2).** The Total Dissolved Solids (TDS) value of Inlet exceeded the WHO standard value of 500 mg/lit by 54 mg/lit (**Graph 3**). The Total Suspended Solids (TSS) is the concentration of organic and inorganic matter in water. Its value of 880 mg/lit exceeds WHO standard value of 500 mg/lit (**Graph 4**). Total Alkalinity (TA) of inlet is higher than the maximum permissible limit of 200 mg/lit indicating high carbonate and bicarbonate salts (**Graph 5**). The Dissolved Oxygen (DO) value of 15.41 mg/lit exceeds the desirable limits 6-8 mg/lit which poses no threat to life form (**Graph 6**). Hardness of water is the amount of Calcium and Magnesium salts present in water (**Graph 7**). The hardness of inlet water is 444 mg/lit which is in very hard range of more than 180 mg/lit of water hardness according WHO standards (2004). The amount of chloride is 56.73 mg/lit which is lower than the permissible value of 250 mg/lit (**Graph 8**). Free CO_2 of 6 mg/lit is dissolved in inlet water sample (**Graph 9**) [2].

Outlet water

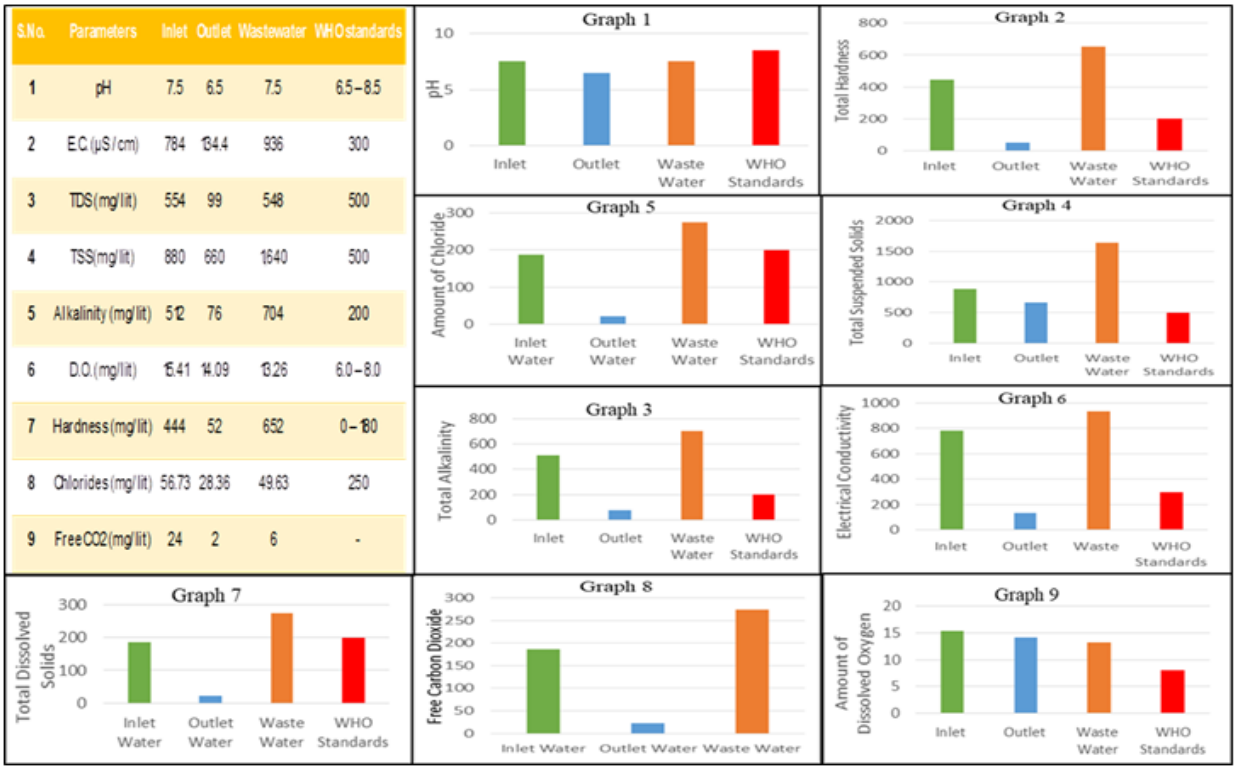
In the pH study of the outlet water, the sample did not exceed the WHO standards i.e., 6.5-8.5 (**Graph 1**). The EC value of outlet is 134.4 µS/cm which is below the WHO permissible limit of 300 µS/cm (**Graph 2**). The TDS value of Outlet water is also within the WHO standard value of 500 mg/lit (**Graph 3**). The TSS value of 660 mg/lit is exceeds the WHO standard value of 500 mg/lit. This indicates high concentration of organic and inorganic matter (**Graph 4**). TA of outlet is below the maximum permissible limit of 200 mg/lit (**Graph 5**). The Dissolved Oxygen (DO) value of 14.09 mg/lit is above the desirable limits of 6-8 mg/lit which poses no health risk to life form (**Graph 6**). The hardness of outlet water is 52 mg/lit which is below 60 mg/lit of water hardness, considered as soft water according WHO standards (**Graph 7**). The amount of chloride is 28.36 mg/lit which is lower than the permissible value of 250 mg/lit (**Graph 8**). Free $CO_2$of 2 mg/lit is dissolved in outlet water sample (**Graph 9**)[2].

Wastewater

In the pH study of the wastewater, the sample did not exceed the WHO standards i.e., 6.5-8.5 (**Graph 1**). The EC value of wastewater is 936 µS/cm exceeds the WHO permissible limit of 300 µS/cm indicating high concentration of ions (**Graph 2**). The Total Dissolved Solids (TDS) value of wastewater is more than the WHO standard value of 500 mg/lit by 48 mg/lit (**Graph 3**). The Total Suspended Solids (TSS) value of 1640 mg/lit exceeds the WHO standard value of 500 mg/lit indicating high concentration of organic and inorganic matter (**Graph 4**). Total Alkalinity of wastewater is higher than the maximum permissible limit of 200 mg/lit (**Graph 5**). The Dissolved Oxygen (DO) value of 13.26 mg/lit exceeds the desirable range 6-8 mg/lit which poses no threat to life form (**Graph 6**). The hardness of wastewater is 652 mg/lit which exceeds the maximum permissible value of 180 mg/lit denoting that the water sample comes under very hard range of water hardness according WHO standards (**Graph 7**). The amount of chloride is 49.63 mg/lit which is lower than the permissible value of 250 mg/lit (**Graph 8**). Free CO_2 of 6 mg/lit is dissolved in wastewater sample (**Graph 9**).

Table and Graphs comparing different water samples for the parameters: pH, Total Dissolved Solids, Total Suspended solids, Electrical Conductivity, Alkalinity, Free Carbon dioxide and Dissolved Oxygen.

S.No.	Parameters	Inlet	Outlet	Wastewater	WHO standards
1	pH	7.5	6.5	7.5	6.5–8.5
2	E.C.(µS/cm)	784	134.4	936	300
3	TDS(mg/lit)	554	99	548	500
4	TSS(mg/lit)	880	660	1640	500
5	Alkalinity (mg/lit)	512	76	704	200
6	D.O.(mg/lit)	16.41	14.09	13.26	6.0–8.0
7	Hardness(mg/lit)	444	52	652	0–180
8	Chlorides(mg/lit)	56.73	28.36	49.63	250
9	FreeCO2(mg/lit)	24	2	6	-



Water quality index

The calculated WQI values of the three samples are classified into five categories: excellent water (WQI < 50), good water (WQI = 50 – 100), poor water (WQI = 100 – 200), very poor water (WQI = 200 – 300), and water unsuitable for drinking (WQI > 300).

Table 1 indicates that the WQI of inlet water and wastewater are of poor and very poor quality respectively and the WQI of outlet water is of excellent quality (Batabyal & Chakraborty, 2015)

Conclusion and Discussion.

In the project, quality assessment of the Inlet, Outlet and Wastewater from the RO plant was done. The inlet is the groundwater which undergoes RO treatment to make it suitable for drinking. The outlet is the purified drinkable form of the inlet water after RO treatment. The wastewater or the reject water is the impure water which is filtered out after RO treatment and is used in washrooms or for watering plants. The three water samples collected underwent various physiochemical tests for analysis. The pH values of all the three samples ranged from 6.5 – 7.5. The pH value is taken for determining acidic or basic nature of water [3]. The pH of inlet water was 7.5. After RO treatment the pH of the outlet water obtained was 6.5 and the pH of wastewater remained same as that of inlet. The WHO standards for pH is in the range 6.5 – 7.5.

Solids dissolved in water are determined by the value of Total Dissolved Solids (TDS), which ranged from 99 – 554 mg/lit. The TDS of inlet water was 554 mg/lit, which after RO treatment significantly reduced to 99 mg/lit. It is desirable for TDS of drinking water to be below 500 mg/lit according to WHO standards. Total Suspended Solids (TSS) are the undissolved solids in water. TSS values of the three water samples widely ranged from 660 – 1640 mg/lit. Before RO treatment TSS of inlet was 880 mg/lit and after treatment it reduced to 660 mg/lit. The TSS of wastewater from the RO plant was significantly high i.e. 1640 mg/lit. WHO recommends TSS of drinking water to be below 500 mg/lit. Alkalinity of three water samples were in the range of 76 – 704 mg/lit. The alkalinity of inlet water was 512 mg/lit and after RO treatment had a notable reduction to 76 mg/lit. The alkalinity of wastewater after the RO treatment was 704 mg/lit which was remarkably high. WHO recommends alkalinity of drinking water to be below 200 mg/lit. The amount of Dissolved Oxygen (DO) in the three samples ranged from 13.26 – 15.41 mg/lit. The amount of DO in inlet water was 15.41 mg/lit and after RO treatment reduced to 14.09 mg/lit. The DO of wastewater was even lower than that of inlet and outlet water i.e. 13.26 mg/lit. WHO recommends DO of drinking to be in range of 6.0 – 8.0 mg/lit but any amount of DO poses no threat to human life. The amount of chlorides in the three samples ranged from 28.36 – 56.73 mg/lit. The amount of chloride in inlet water was 56.73 mg/lit before treatment by RO plant. After the treatment, the amount of chloride in outlet water reduced to 28.36 mg/lit. The amount of chloride in wastewater was 49.63 mg/lit. According to WHO standards, it is desirable for amount of chloride to be below 250 mg/lit since high amounts of chloride can impart salty taste to water. Free CO_2 of the three samples ranged from 2 – 6 mg/lit. Free CO_2 is the Carbon dioxide dissolved in water. The amount of free $CO_2$of inlet water was 6 mg/lit and after RO treatment, the amount of free CO_2in outlet reduced to 2 mg/lit. The wastewater had amount of free CO_2 of 6 mg/lit. There are no WHO standards given for maximum permissible amount of free CO_2in drinking water. The Electrical Conductivity (EC) is measured to determine the ionic concentration of given sample. The value of EC for the three water samples ranged from 134.4 – 936 µS/cm. The EC of inlet water was 784 µS/cm and after RO treatment, the EC of outlet obtained reduced to 134.4 µS/cm. The EC of wastewater was more than the inlet and outlet water i.e., 936 µS/cm. WHO recommends EC of drinking water to be below 300 µS/cm. Hardness of water is the amount of Calcium and Magnesium salts dissolved in water. Hardness in the three water samples varied from 52 – 652 mg/lit. Inlet water had the hardness of 444 mg/lit. After RO treatment, the hardness of outlet water reduced to 52 mg/lit. The wastewater obtained had the highest hardness 652 mg/lit. According to WHO standards, hardness of water below 60 mg/lit is soft water, between 60 – 120 mg/lit is moderately hard water, between 120- 180 mg/lit is hard water and more than 180 mg/lit is considered as very hard water (Guettaf et al, 2014).

By determining the physical and chemical parameters like pH, EC, TDS, TSS, Alkalinity, DO, Hardness, Chlorides and Free CO_2 and comparing it with the WHO standards, it was ascertained that the drinking water is well within the WHO standards. By calculating the WQI of all the three samples by taking 6 parameters pH, TDS, TH, Chloride, EC, TA, and TSS it was found that the WQI of Inlet and Wastewater was very high indicating very poor water quality due to high ionic and dissolved solute concentration and the WQI of outlet water was low indicating excellent water quality. Therefore, the outlet water which is also the final purified RO water, is safe for consumption (Batabyal & Chakraborty, 2015)

Acknowledgement

Authors are thankful to the Principal, Lab Assistants and Caretakers of Kalindi College for their timely assistance and encouragement to complete the assessment.

References

[1] Chonde, S. G., Mohite, A. S. and Raut, P. D. (2014). Studies on drinking water quality at public transport of drinking stations from Kolhapur and Sangli city. Adv. Appl. Sci. Res., 5(2):316-327
[2] Batabyal, A. K., & Chakraborty, S. (2015). Hydrogeochemistry and water quality index in the assessment of groundwater quality for drinking uses. Water Environment. Research, 87, 607–617.
[3] Guidelines for drinking-water quality: fourth edition incorporating the first addendum. Geneva: World Health Organization; 2017. License: CC BY-NC-SA 3.0 IGO
[4] Guettaf M, Maoui A, Ihdene Z (2014) Assessment of water quality: a case study of the Seybouse River (North East of Algeria).Appl Water Sci. doi: 10.1007/s13201-014-0245-z
[5] Panigrahi, Ramakanta; Behera, Tusharkanti. 2013. Laboratory Manual for engineering lab 1st Edition. Jatni, Bhubaneswar: Centurion University.