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# A PRELIMINARY STUDY ON WATER QUALITY OF KHREW INDUSTRIAL AREA PULWAMA, KASHMIR.

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Abstract

The demand for fresh spring water recently increased due to intensive domestic, industrial irrigation practices which typically caused depletion of water resources and deterioration of water quality The aim of this research was to study the water characteristics in Khrew industrial area. For the present study, all the three types of fresh water sources available in the area i.e. Spring water, Stream water and Tap water, were taken and the study was carried out from the month of August to December, 2017 on monthly basis and analyzed for Temperatute, pH, electrical conductivity (EC), Dissolved Oxygen (DO), total hardness (TH), calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), Alkalinity, free Carbon dioxide ($CO_2$), chloride ($Cl^-$) and Orthophosphorus . The water temperature ranged from 12°C to 15°C at site-1 (Spring water), 10°C to 17°C at site-2 (stream water), and 11°C to 16°C at site-3 (Tap water), within permissible limits as recommended by World Health Organization standards, 2008 and Indian standards Specification for Drinking water, Second Revision, 2012).The water pH ranged from 7.32 – 7.65 at site-1 (spring water), 6.50 – 7.45 at site-2 (Stream water) and 7.26 – 7.90 at site-3 (Tap water), within the permissible limits as recommended by World Health Organization standards, 2008.The DO ranged from 4 mg/L – 6 mg/L at site-1 (spring), 4.6 mg/L – 6.6 mg/L at site-2 (stream) and 4.8 mg/L – 5.9 mg/L at site-3 (Tap water), within permissible limits as recommended by World Health Organization Standards, 2008 and IS, 2012. Maximum DO was found in stream and minimum was found in spring during the present study.The EC, free $CO_2$, chloride, total alkalinity, total hardness, magnesium hardness, calcium hardness and ortho-phosphorus were also within permissible limits for all the three sites analyzed, as recommended by world Health Organization standards, 2008 and Indian Standards Specification for Drinking water, Second Revision, 2012.The study revealed that all the parameters were within permissible limits at all the three sites as recommended by WHO, 2008 and IS, 2012)

## Introduction

Water is regarded as the most important and valuable natural resource on which all life on earth ultimately depends. Water plays an important role in the development of different sectors of the economy, including agriculture, cattle production, forestry, industrial electricity generation, fisheries, and other innovative activities (Bouslah et al. 2017; Tyagi et al. 2013). But, with the continuous growth of the human population the demand for water, and the sustainability of the freshwater supply is significantly threatened due to extensive depletion of groundwater, surface water contamination, and the effects of climate change (IPCC 2007; Poudel and Duex 2017). Fresh water is already a limiting resource in many parts of the world. In the next century, it will become even more limiting due to increased population, urbanization and climate change (Jackson *et al.*, 2001). Thus, information on water resources and their suitability for use is mandatory for spatial planning and sustainable development. This is of particular importance in arid and semiarid areas, where water resources are limited and the long-term average precipitation is decreasing (Barakat et al. 2018; Mishra and Singh 2010; Tallaksen and Van Lanen 2004). Groundwater also makes up about 20 percent of the world's fresh water supply and is about 0.63 percent of the entire world's water, so it is again important sources of portable water throughout the world (Khanam and Singh, 2014). The quality of ground water is changing due to human activities (Gehrels *et al.*, 2001). Due to inadequate

availability of surface water, to meet the requirements groundwater is one of the important options to supplement the ever-increasing demand of water (Tyagi *et al.*, 2009). Among the states of India, the state of Jammu and Kashmir lies between 33° 20′ and 34° 54′N latitudes and 73° 55′ and 75° 35′E longitudes and covers an area of 222236 sq km. The state is called as paradise on earth with ample water resources present in the form of lakes (Dal, Walur, Manasbal, Mansar, etc.), rivers (Indus, Jhelum, Chenab, Beas etc) and glaciers besides nice reserves of ground water. The quality of these water bodies is deteriorating day by day and the water as a resource is becoming scarce due to anthropogenic pressure. The fresh water bodies of state are under huge anthropogenic pressure due to various man-made events and processes like urbanization, catchment degradation and contamination through sewage and sewerage that have built up enough pressure on the fresh water bodies of the valley resulting in mass degradation of these ecosystems. In the valley of Kashmir, Khrew is one of the heavily industrialized areas especially in cement production sector. In addition to air and soil quality degradation the water resources in general and drinking sources particular e area has been also damaged to a large extent. The present study is carried with aim to assess the drinking water quality of the Khrew area in the back drop of heavy cement industrialization of the area. Khrew is semi urban area some 22 km away from city Srinagar of Jammu and Kashmir state. The area is surrounded with Zabarwan mountain range and large numbers of limestone deposits are present in these hills. Khrew town is gifted with abundant freshwater resources in the form of springs and small streams. More than seven springs are found inside the main town of Khrew and these springs act as a source for a large number of streams flowing through entire town of Khrew. These small streams form a network inside the town and finally combine to form a large stream.
Due to heavy industrialization the water resources epically, the drinking water resources has been contaminated to larger extent. It is in this context that the present study was conducted on some fresh water resources of Khrew area. The primary objectives of the study are as under:

1. To assess the portability of drinking water in the town.
2. To see the effect of cement factories on these water sources.
3. To have an insight of pollution status of these sources.
4. To gain an understanding of the degradation of the water quality that might have taken place due to increase in urbanization, cement factories and domestic waste generated by these activities.

Study area:
The present study was carried out to assess the quality of some fresh water resources of Khrew area (Fig. 1a), situated in district Pulwama of Kashmir valley of J&K state, located about 22 km from Srinagar. Khrew is a town and a notified area committee of Pulwama. It is surrounded on all sides by small villages as Androssa, Shar, Wayan, Bathen, Nagandar, and Wahabsbun. It is situated at an altitude of 1607 m above the sea level with geographical coordinates of 34.02°N and 74.99°E and is spread over an area of 12 square kilometers. Khrew is a main economic zone of Jammu and Kashmir because of presence of large number of cement factories and a large area of land under saffron cultivation. There are more than seven springs present in Khrew and number of streams flow from these springs. But unlimited cement factories pollution has degraded the water quality of these precious springs and streams.
For the present study, all the three types of fresh water sources available in the area i.e. Spring water, Stream water and Tap water, were taken and the study was carried out from the month of August to December, 2017 on monthly basis.



**Khrew Pulwama**
**Map Showing Study Area (Fig 1a)**

Methodology

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The samples were analyzed for pH, temperature, total hardness, total alkalinity, Electrical conductivity (EC), Ca2+, Mg2+, K+, Dissolved Oxygen (DO), free Carbon dioxide $CO_2$, Cl−, Orthophosphorus in accordance with the procedures delineated in the standard methods described by Motsara and Roy (2008) and APHA (1995).

## Results and Discussion

The results obtained for all the three sites are depicted in (Figure 1a). For site-1 the value ranged from 12°C to 15°C with lowest value of 12°C in the month of August against 15°C in the month of December with an average value of 13.2°C. At site-2 the values ranged from 10°C to 17°C with lowest value of 10°C in the month of December against 17°C in the month of August with an average value of 14°C. For site-3 the values ranged from 11°C to 16°C with lowest value of 11°C in the month of December against 16°C in the month of August with an average value of 14.4°C.Water temperature is a factor indicating the quality of water. Temperature measurements indicate the trend of biochemical and biological activities in water body. Temperature influences aquatic life and concentration of dissolved gases like oxygen and carbon dioxide. During the present study, at Site-1, the minimum and maximum values were recorded during August and December respectively. This could be due to the fact that water has a higher heat capacity, so it takes longer to heat up and longer to cool down, so relatively it is hotter in winter and colder in summer. The minimum water temperature of site-I during summer could also be due to shading effect of chinar trees along its periphery (Pandit *et al, 2005*). Similar observations were recorded by Makwe and Chup (2013), while carrying out the study on seasonal variations in physico-chemical properties of groundwater. At site-2, a stream water source the minimum and maximum values of water temperature were recorded during December and August respectively. This increase and decrease in stream temperature results from land use and climate change (Beschta *et al*, 1987). Kadhim (2014) recorded the same observations while studying physico-chemical characteristics as index of water quality in Euphrates River. At site-3, tap water sourse the minimum and maximum values of water temperature was recorded during the months of December and August respectively. The pipes from tank to the house are only buried a foot or so deep, and the ground gets colder by far in the winter and so are the pipes and water flowing inside them.

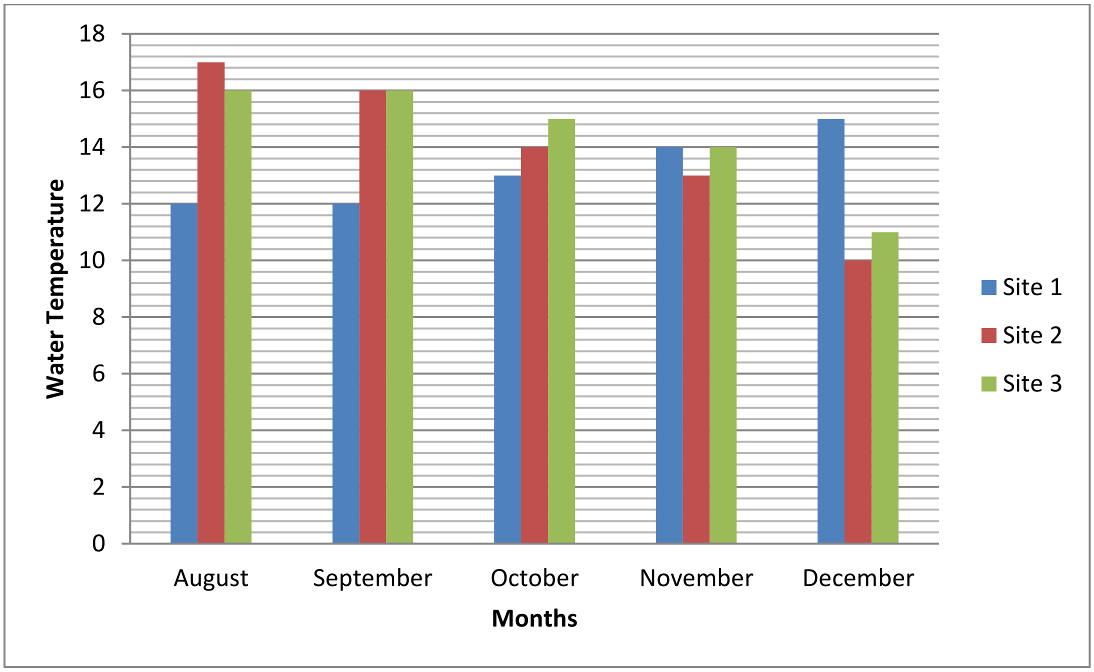


**Fig. 1a: Monthly variation in Water Temperature (°C) at different sites of Khrew during alternative months from August – December, 2017.**

**2. pH**

The results obtained for all the three sites are depicted in (Figure 2a). For Site-1 the pH value ranged from 7.32 to 7.65 with lowest value of 7.32 in the month of August against 7.65 in the month of December with an average value of 7.43. For Site-2 the value ranged from 6.50 to 7.45 with lowest values of 6.50 in the month of December against 7.45 in the month of October with an average value of 7.03 and similarly for Site-3 the value ranged from 7.26 to 7.90 with lowest value of 7.26 in the month of November against 7.90 in the month of September with an average value of 7.59. The pH value is the logarithm of reciprocal of hydrogen ion activity in moles per liter. The pH in natural water is the carbonate which comprises $CO_2$ and $HCO_3$. It is a measure of the intensity of acidity or alkalinity. The pH of water controls the chemical state of many nutrients including phosphates, ammonia, $CO_2$ and trace elements (Goldman and Horne, 1983). In present study, at Site-1(spring) the minimum values of pH were recorded in the month of August and the maximum values were recorded during the month of December respectively. The lowest value may be attributed to lower rates of photosynthesis (Bhat et al, 2013) also revealed by Agarkar and Garode (2001). While at Site-2, (stream) the pH was minimum during the month of December and maximum during the month of October. The increase in pH may be associated with increase in dissolved oxygen, produced as a result of photosynthesis (Wetzel, 1975). For Site-3, minimum values of pH were recorded in the month of November and maximum during the month of September respectively. These results resemble with the observations of Mahdi *et al* (2006) and Pandit *et al* (2001). The overall pH of all the three sites was observed to be slightly alkaline.

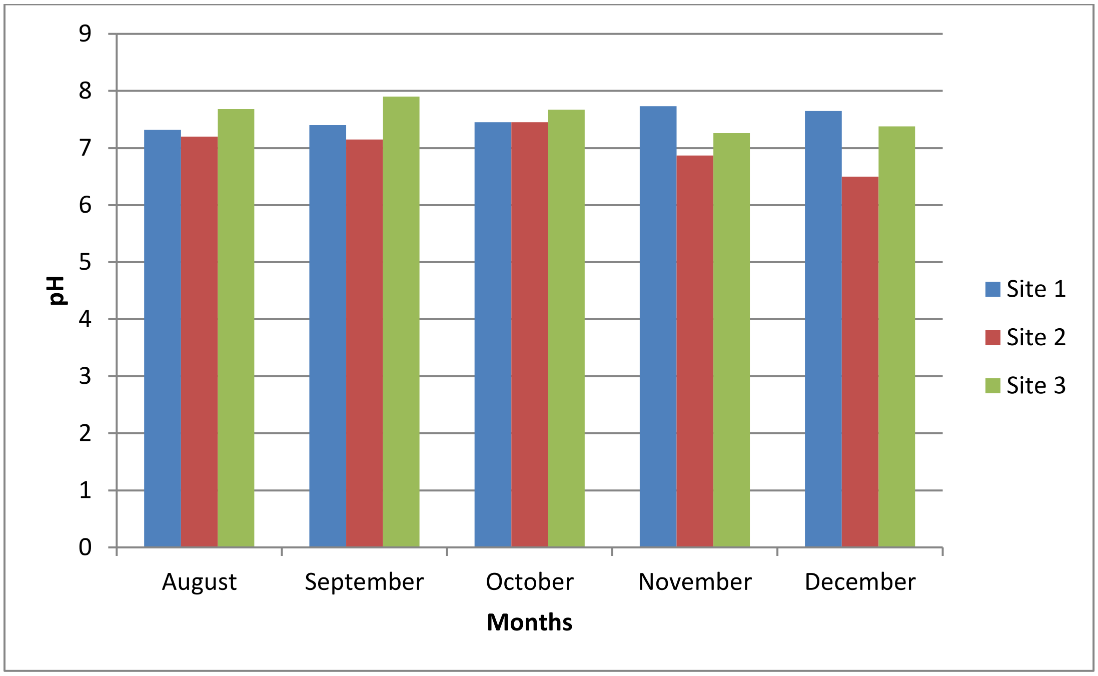


**Fig 2a: Monthly variation in Water pH at different sites of Khrew during alternative months from August – December, 2017.**

### 3. Electrical conductivity

The results obtained for electrical conductivity for all the three sites are depicted in (Figure 3a). For Site-1 the values of electrical conductivity ranged from 450 *µs/cm* to 580 *µs/cm* with lowest value of 450 *µs/cm* in the month of December against highest values of 580 *µs/cm* in the month of August with an average of 517 *µs/cm*. For Site-2 the values ranged from 500 *µs/cm* to 567 *µs/cm* with lowest of 500 *µs/cm* in the month of August against the highest values of 567 *µs/cm* in the month of November with an average of 543.4 *µs/cm*. For Site-3 the values ranged between 495 *µs/cm* to 530 *µs/cm* with lowest of 495 *µs/cm* in the month of December against the highest value of 530 *µs/cm* in the month of August with an average of 514 *µs/cm*.Electrical conductivity (EC) is a measure of water capacity to convey electric current. Conductivity becomes an indicator of dissolved salts present in any water supply, which is measure of salinity that affects the taste of portable water. During present study, for Site-1, the minimum value of electrical conductivity was recorded in the month of December and maximum value was recorded in the month of August while as for Site-3 the minimum and maximum values were recorded in the months of December and August respectively. The high values might be due to increased concentration of dissolved solids (Tareq *et al*, 2013). Dutta *et al*, (2010) observed the same trend while studying water quality at two spring sites in Kashmir. At site-2, the minimum and maximum values were recorded in the months of August and December respectively. The reverse trend in the values of electrical conductivity at Site-2, might be due to the addition of various ions added to water from catchment area because of good precipitation in these months, which in turn regulates the conductivity of water in winter (Golterman, 1975). Similar observations were recorded by Bhat *et al*, (2009) while studying the electrical conductivity of Tangpana Spring.

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Volume : 52, Issue 4, No. 1, April : 2023

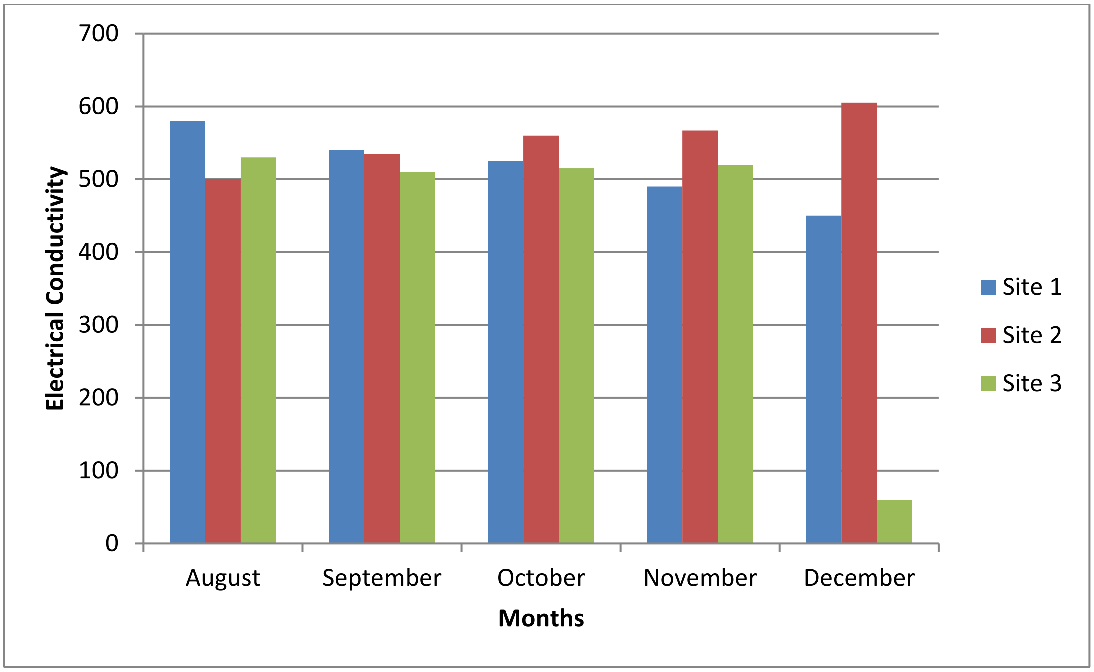


**Fig 3a: Monthly variation in Electrical Conductivity *(μs/cm)* at different sites of Khrew during alternative months from August – December, 2017.**

**4. Dissolved Oxygen**

The results obtained for Dissolved Oxygen for all the three sites are depicted in (Figure 4a). For Site-1 the value ranged from 4 mg/L to 6 mg/L with lowest value of 4 mg/L in the month of December against 6 mg/L in the month of August with an average value of 4.88 mg/L. For Site-2 the values ranged from 4.6 mg/L to 6.6 mg/L with lowest value of 4.6 mg/L in the month of August against 6.6 mg/L in the month of December with an average value of 5.52 mg/L. For Site-3 the values ranged from 4.8 mg/L to 6.9 mg/L with a lowest value of 4.8 mg/L in the month of August against 5.9 mg/L in the month of December with an average value of 5.38 mg/L.Dissolved oxygen frequently is the key substance in determining the extent and kinds of life in a water body. Dissolved oxygen is also an important index of water quality. The solubility of oxygen in water depends upon water temperature, the partial pressure of oxygen in the atmosphere and the salt content of the water. It provides valuable information about the biological and biochemical reactions in water. It is required for the metabolism of all aquatic organisms. Oxygen deficiency is fatal to many aquatic animals such as fish. Aerobic bacteria and aquatic life such as fish must have DO to survive. The presence of oxygen can be equally fatal to many kinds of anaerobic bacteria. Aerobic wastewater treatment process use aerobic and facultative bacteria to breakdown the organic compounds found in wastewaters. Wastewater treatment facilities such as lagoons or ponds, trickling filters and activated sludge plants depend on these aerobic bacteria to treat sewage. The same type of aerobic wastewater treatment process occurs naturally in streams and ponds if organic matter is present, turning these bodies of water into “aerobic wastewater treatment plants”. If sufficient oxygen is not naturally supplied through wind and turbulence to replace the depleted oxygen, the body of water will develop a low DO and become anaerobic or septic. The results of septic water bodies include fish kill and anaerobic odors. The DO test is used to ensure that there is enough dissolved oxygen present to keep the process from becoming septic. The present study revealed that for Site-1, (spring) the minimum and maximum values were recorded in December and August respectively. For Site-2, (stream) and Site-3, (tap) showed reverse trend as compared to site-1, (spring). The minimum and maximum values at Site-2 and Site-3 were recorded in August and December. All the three sites showed an inverse relationship with temperature. The cold water contains more oxygen as compared to warm water as DO is inversely proportional to temperature (Hynes, 1960). Rani *et al* (2004) also reported lower values of DO in summer due to higher rate of decomposition of organic matter and limited flow of water in low holding environment due to high temperature. Similar observations were recorded by Manzoor *et al*, (2011).

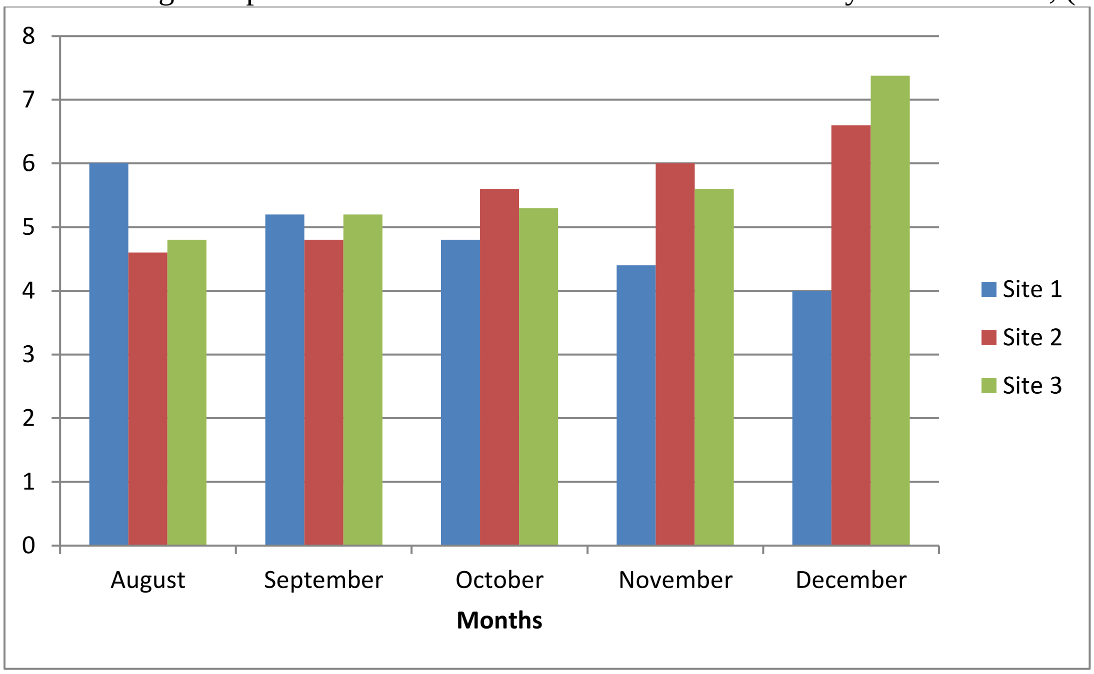


**Fig 4a: Monthly variation of Dissolved Oxygen (mg/L) at different sites of Khrew during alternative months from August – December, 2017.**

**5. Free $CO_2$**

The results obtained for free Carbon Dioxide for all the three sites are depicted in (Figure 5a). For Site-1 the values ranged from 10 mg/L to 16 mg/L with lowest value of 10 mg/L in the month of August against 16 mg/L in the month of December with an average value of 12.4 mg/L. For Site-2 the values ranged from 7 mg/L to 12 mg/L with lowest value of 7 mg/L in the month of December against 12 mg/L in the months of August and October with an average value of 10.06 mg/L. For Site-3 the values ranged from 12 mg/L to 16 mg/L with lowest value of 12 mg/L in the month of December against 16 mg/L in the month of September with an average value of 13.8 mg/L.Free carbon dioxide exists naturally in water as it is produced by respiratory process in water and sediments and can also enter water from the atmosphere. Carbon Dioxide and its ionization product bicarbonate ion and carbonate ion have an extremely important influence upon the chemistry of water. The carbonate system is the most important acid-base system in natural waters because it controls pH. When Carbon Dioxide dissolves in water it yields carbonic acid. The dissociation of carbonic acid yield hydrogen ($H^+$) and bicarbonate ion. In the present study the free Carbon Dioxide content recorded for Site-1 (spring) was minimum during August and maximum during December. The lower value in August is attributed to photosynthetic activity by aquatic flora and fauna (Jyoti *et al*, 2007). For Site-2 (stream) the minimum and maximum values were recorded in the months of December and August/October respectively. ForSite-3 (tap) the minimum and maximum values were recorded in December and September respectively. The maximum value may be due to the behavior of

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 4, No. 1, April : 2023

Carbon Dioxide with pH as both are inversely related as an increase in $CO_2$ concentration in water results in decrease in its pH due to the formation of carbonic acid (Chandler, 1970). Carbon Dioxide in natural waters is required for the photosynthetic production of biomass by algae and in some cases is a limiting factor. High levels of $CO_2$ produced by the degradation of organic matter in water can cause excessive algal growth and productivity.

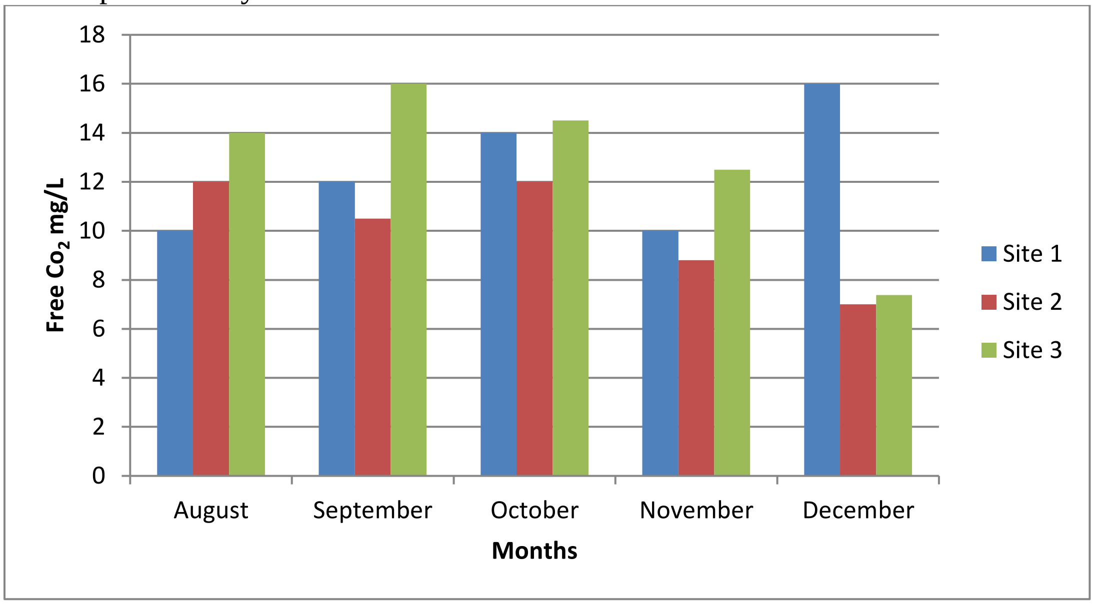


**Fig 5a: Monthly variation in Free $CO_2$ (mg/L) at different sites of Khrew during alternative months from August – December, 2017.**

## 6. Chloride

The results obtained for chloride concentration for all the three sites are depicted in (Figure 6a ). For Site-1 the value ranged from 15.96 mg/L to 22.96 mg/L with lowest value of 15.96 mg/L in the month of December against 22.96 in the month of August with an average value of 18.96 mg/L. For Site-2 the value ranged from 17.96 mg/L to 25.95 mg/L with lowest value of 17.96 mg/L in the month of December against 25.95mg/L in the month of August with an average of 21.05 mg/L. For Site-3 the values ranged from 14.97 mg/L to 18.96 mg/L with lowest value of 14.97 in the month of December against 18.96 mg/L in the month of August with an average of 16.66 mg/L.Chlorine in the form of chloride ion is one of the major anion in water and waste waters. Chlorides are one of the major constituents in drinking water. The salty taste produced by chloride concentrations is variable and dependent on chemical composition of water. The presence of low chloride contents indicates the purity of water, high concentrations of chloride is considered to be the indicator of pollution. The salty taste produced by chloride concentrations is variable and dependent on chemical composition of water. Some waters containing 250 mg /L of chloride may have a detectable salt taste if the cation is Sodium, on the other hand the typical salty taste may be absent in waters containing as much as 1000 mg/L when the predominant cations are calcium and magnesium. During the present study at Site-1, (spring) the minimum and maximum values were recorded during the months of December and August respectively. For Site-2, (stream) the minimum values were recorded during December and maximum in August. Similarly, for Site-3, (tap) the minimum and maximum values were also recorded during the months of December and August respectively. The high chloride levels in August (summer) have been attributed to organic pollution of animal origion by Zutchi and Khan, 1988; Wani and Subla, 1990. Jana (1973) and Govindan and Sundaresan (1979) observed that higher concentration of chloride in summer could be due to sewage mixing, increased temperature and higher runoff from catchment. Similar observations were recorded by Khan *et al*, (2012).

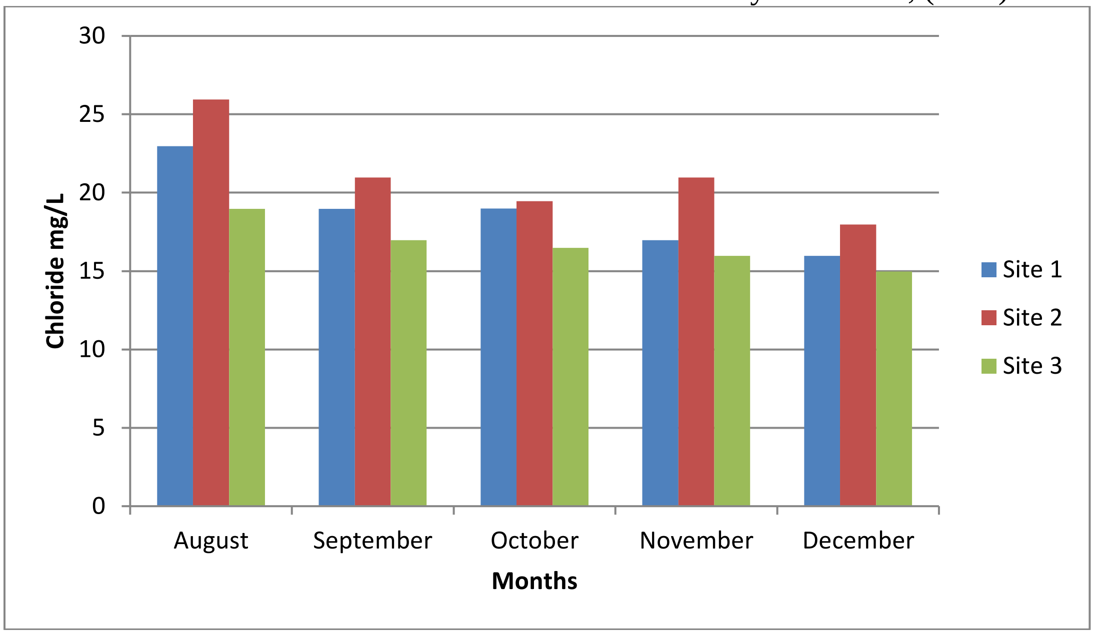


**Fig 6a: Monthly variation in Chloride (mg/L) at different sites of Khrew during alternative months from August – December, 2017.**

**7. Total alkalinity**

The results obtained for total alkalinity for all the three sites are depicted in (Figure 7a ). The total alkalinity was only due to bicarbonates and hydroxide ions as carbonates were absent at every site. The alkalinity is mainly constituted by the bicarbonate ion which represents the main carbon source for assimilation during photosynthesis (Kaul *et al*, 1980). For Site-1 the values ranged from 56.5 mg/L to 60 mg/L with lowest value of 56.5 mg/L in the month of August against 60 mg/L in the month of November with an average value of 57.82 mg/L. For Site-2 the values ranged from 54 mg/L to 62 mg/L with lowest value of 54 mg/L in the month of August against 62 mg/L in the month of December with an average value of 56.72 mg/L. For Site-3 the values ranged from 44 mg/L to 49 mg/L with lowest value of 44 mg/L in the month of September against 49 mg/L in the month of November with an average value of 46.4 mg/L.Alkalinity is the capacity of water to accept $H^+$ ions (protons) or capacity of water to neutralize acid. Alkalinity is important in water treatment and in the chemistry and biology of natural waters. Highly alkaline water often has a high pH and generally contains elevated levels of dissolved solids. Alkalinity serves as a pH buffer and reservoir for inorganic carbon, thus helping to determine the ability of water to support algal growth and other aquatic life, so it can be used as a measure of water fertility. In natural waters, carbonates, bicarbonates, phosphates and hydroxides are considered as predominant bases hence alkalinity is expressed as total alkalinity. For site-1, (spring) the minimum value was recorded during the month of August and maximum in November respectively. For site-2, (stream) the minimum value was recorded in the month of August and maximum during December. For site-3, (tap) the minimum and maximum values were recorded during the months of September and November respectively. A decline during summer (August and September) may be due to increase in the volume of water by monsoon rains (Borana *et al*, 2013). Similar observations of seasonal fluctuation were observed by Khan *et al*. (1978) while studying the physico-chemical parameters of pond Chaytal. Meshram, (1996) observed that the carbonate alkalinity of Wadali lake was found to be positively correlated with temperature and conductivity and negatively correlated with total phytoplankton, while as inverse correlation was seen between bicarbonate alkalinity and total phytoplankton.

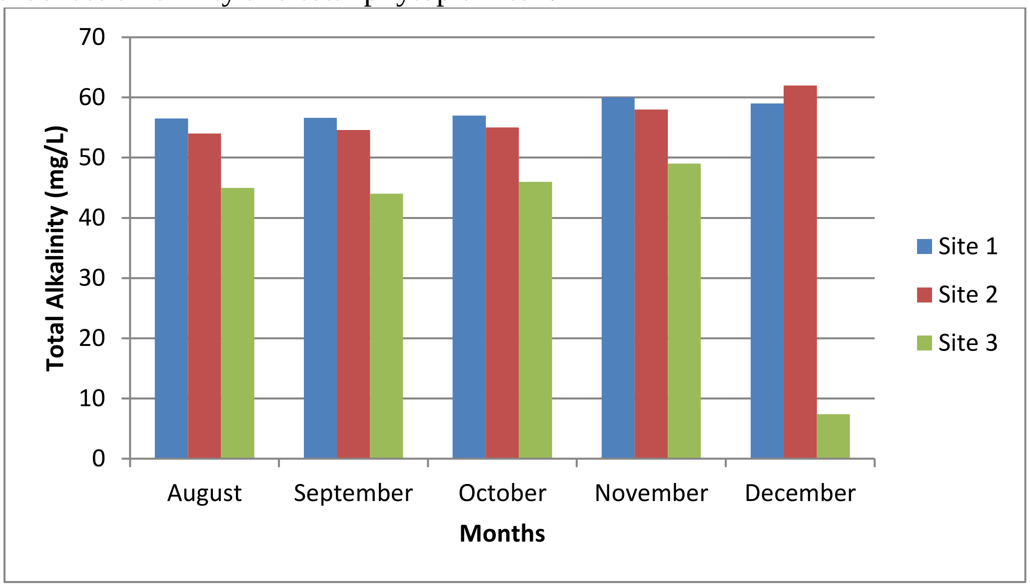


**Fig 7a: Monthly variation in Total Alkalinity (mg/L) at different sites of Khrew during alternative months from August – December, 2017.**

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**8. Total Hardness**

The results obtained for total hardness for all the three sites are depicted in (Figure 8a). For Site-1 the values ranged from 110 mg/L to 140 mg/L with lowest value of 110 mg/L in the month of December against the highest value of 140 mg/L in the month of August with an average value of 123.2 mg/L. For Site-2 the values ranged between 116 mg/l to 124 mg/L with lowest value of 116 mg/L in the month of September against the highest value of 124 mg/L in the month of November with an average value of 120 mg/L. At Site-3 the values ranged from 92 mg/L to 110 mg/L with lowest value of 92 mg/L in the month of December against the highest value of 120mg/L in the month of August with an average value of 102.4 mg/L.Water hardness reflects mainly the contents of calcium and magnesium ions combined with carbonates and bicarbonates but may also be combined with sulphides and chlorides. Hard water is the water that has high mineral contents. The presence of total hardness of water is almost entirely due to the presence of Calcium and Magnesium. These salts add to water when it percolates through deposits of limestone and chalk which are largely made up of Calcium and Magnesium carbonates. Occasionally Zinc and Iron are also present in the form of carbonates or sulphates, the presence of free $CO_2$ or large quantities of Sodium Chloride may add the hardness of water. During the present study at Site-1(spring) the minimum value was found during the months of November and December and maximum during the months of August and September respectively. Similarly, at Site-3(tap) the minimum values were found during the months of November and December and maximum during the months of August and October respectively. The low hardness during the months of November/December may be probably due to high dilution during wet season (Anhwage, 2012). At Site-2(stream) the minimum values were recorded during the months of September/October and while maximum values were found during the months of November/December respectively. The higher values of hardness being attributed to the inflow of rainwater carrying good amount of suspended salts (Patil *et al*, 1986). According to Barret (1953), hard water is more productive than soft water. Calcium and magnesium are the most abundant divalent cationic elements in the fresh water of Kashmir with calcium generally the dominant one (Zutchi, *et al*, 1988) which is related to the presence of lime rich rocks in the catchment area of these water bodies (Wani and Subla, 1990).

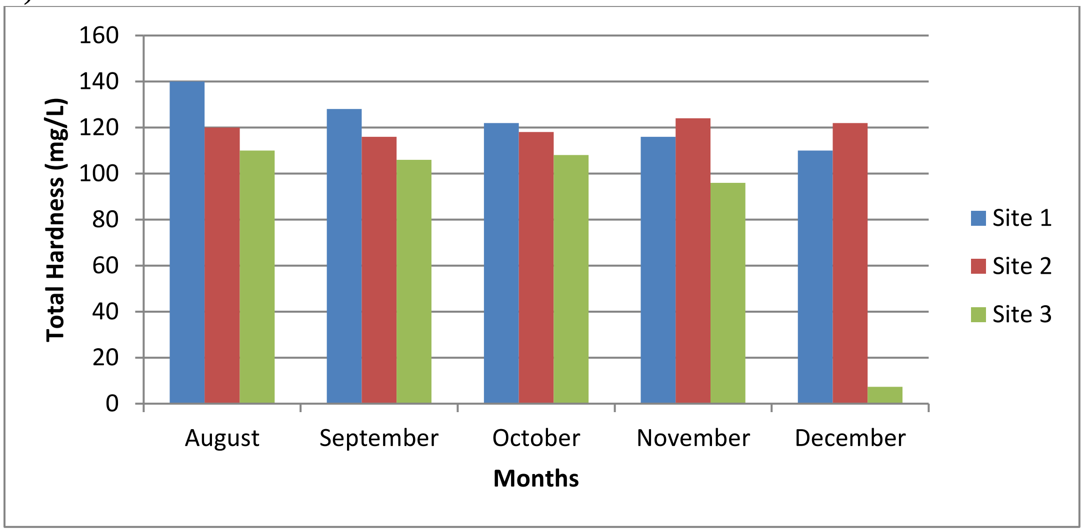


**Fig 8a: Monthly variation in Total Hardness (mg/L) at different sites of Khrew during alternative months from August – December, 2017.**

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**9. Magnesium Hardness**

The results obtained for magnesium hardness for all the three sites are depicted in (Figure 9a ). For Site-1 the values ranged between 47 mg/L to 53.9 mg/L with lowest value of 47 mg/L in the month of December against the highest value of 53.9 mg/L in the month of August with an average value of 49.28 mg/L. For Site-2 the value ranged from 50.5 mg/L to 57 mg/L with lowest value of 50.5 mg/L in the month of November against the highest value of 57 mg/L in the month of August with an average value of 53.64 mg/L. For Site-3 the values ranged between 43.5 mg/L to 49.1 mg/L with lowest value of 43.5 mg/L in the month of November against the highest value of 49.1 mg/L in the month of August with an average value of 46.12 mg/L.Hardness caused by magnesium is called as magnesium hardness. Magnesium is needed for more than 300 biochemical reactions in the body and thus important for living forms. The present study revealed that at site-1(spring) the maximum values were found during the months of August/September and minimum during the months of November/December respectively. Similarly, for site-3(tap) the minimum values were found during the months of October/November/December and maximum during the months of August/September respectively. For site-2(stream) the minimum values were found during the months of November/December and maximum during the months of August/September respectively. The increase in magnesium hardness during the months of August and September may be due to evaporation of surface water and lowering down the hardness due to heavy rains in monsoon (Bagde and Verma, 1985). Similar observations were

Industrial Engineering Journal
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Volume : 52, Issue 4, No. 1, April : 2023

recorded by Ramesh *et al*, (2014).

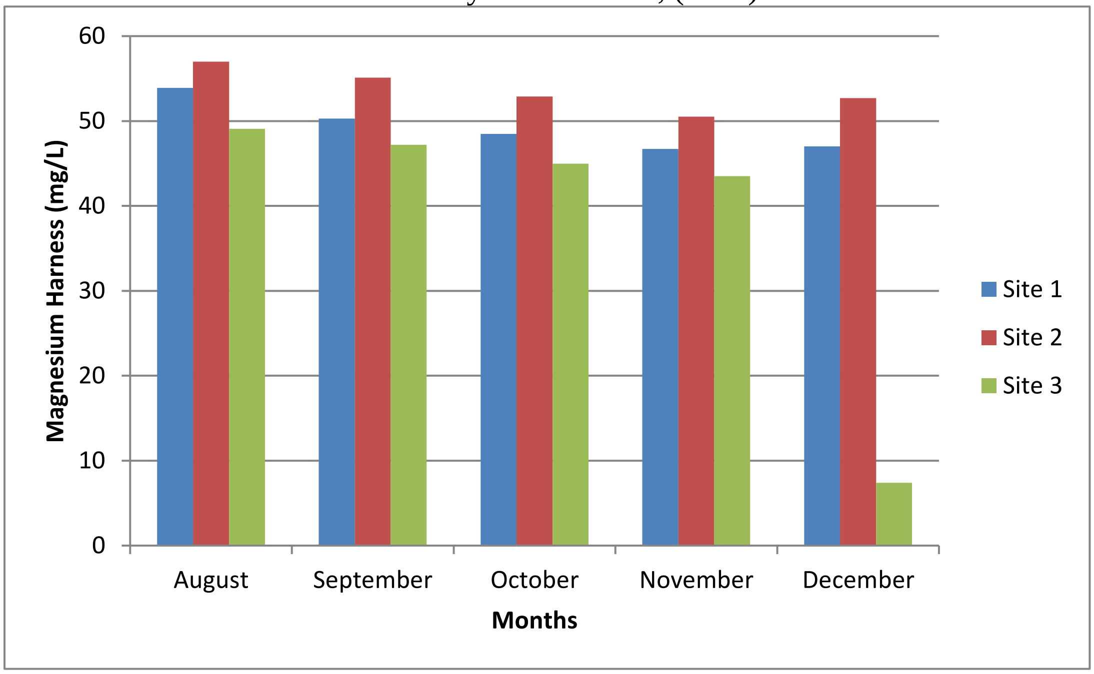


**Fig 9a: Monthly variation in Magnesium Harness (mg/L) at different sites of Khrew during alternative months from August -December, 2017.**

**10. Calcium Hardness**

The results obtained for calcium hardness for all the three sites are depicted in (Figure 10a). For Site-1 the results ranged from 63 mg/L to 86.1 mg/L with lowest value of 63 mg/L in the month of December against 86.1 mg/L in the month of August with an average value of 73.92 mg/L. For Site-2 the values ranged from 60.9 mg/L to 73.5 mg/L with lowest value of 60.9 mg/L in the month of September against 73.5 mg/L in the month of November with an average value of 66.63 mg/L. For Site-3 the values ranged between 46.2 mg/L to 63 mg/L with the lowest value of 46.2 mg/Lin the month of December against 63 mg/L in the month of October with an average value of 56.28 mg/L.Calcium is essential for various metabolic processes in all living organisms including man. Calcium is directly related to hardness. In the present study for site-1, (spring) the minimum and maximum values were found during the months of December and August respectively. For site-3, (tap) the minimum value was found during the month of December and maximum during the month of august. The increase in calcium hardness during August (summer) may be due to evaporation of surface water and lowering down the hardness due to heavy rains in monsoon (Bagde and Verma, 1985; Beena *et al*., 2001). For site-2, (stream) the maximum and minimum values were recorded during the months of November and September respectively. The higher values of calcium during these months may be attributed to prevailing low temperature, which increases the calcium solubility (Borana *et al*., 2013). The concentration of calcium hardness was found more than that of magnesium hardness during present study. The reason for this is the dominance of calcium in fresh water's of Kashmir (Zutchi *et al*, *1988)* which is related to the presence of lime rich rocks in the catchment areas of these water bodies (Wani and Subla, 1990).

Industrial Engineering Journal
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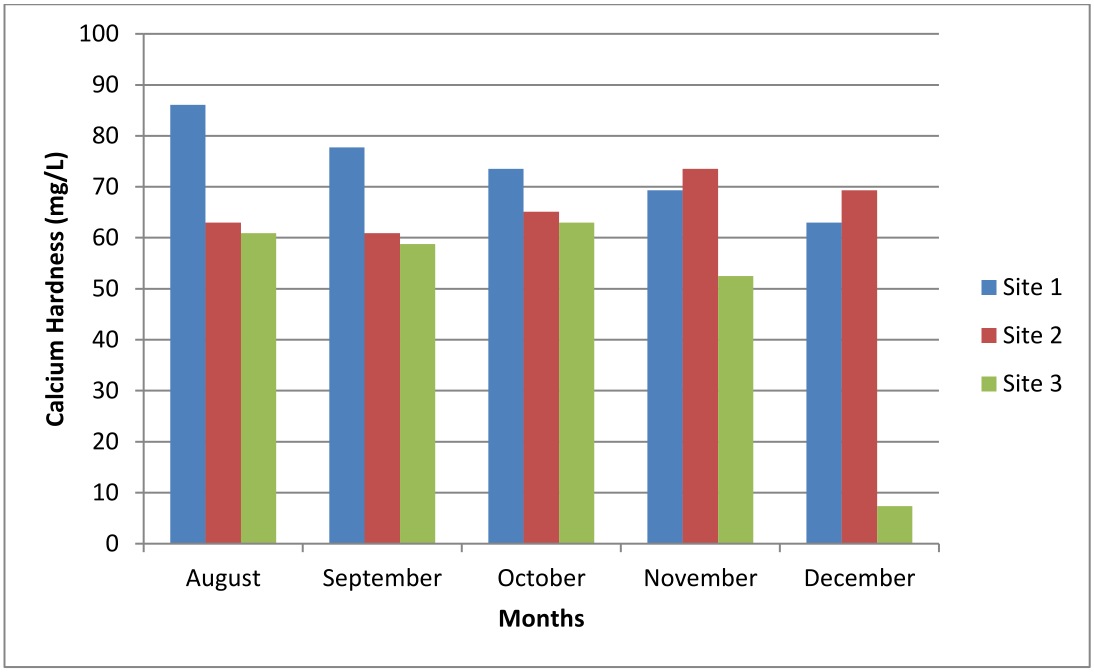


**Fig 10a: Monthly variations in Calcium Hardness (mg/L) at different sites of Khrew during alternative months from August – December, 2017.**

## 11. Ortho – phosphorus

The results obtained for ortho – phosphorus for all the three sites are depicted in (Figure 11a). For Site-1 the values ranged from 230µg/L to 420 µg/L with lowest value of 230 µg/L in the month of December against 300 µg/L in the month of August with an average of 322 µg/L. For site-2 the values ranged from 180 µg/L to 410 µg/L with lowest value of 180 µg/L in the month of November against 410 µg/L with an average of 274 µg/L. For Site-3 the values ranged from 60 µg/L to 100 µg/L with lowest value of 60 µg/L against 100 µg/L with an average value of 80 µg/L.Phosphorus may be found in different forms in water and wastewater including dissolved form (orthophosphate). During the present study the orthophosphate concentration was recorded to be minimum in during the month of December and maximum during the month of August for site-1(spring). The lower values are attributed to decrease in decomposition rate in winters (Bhat and Yousf, 2004). For site-2 (stream) the minimum and maximum values were recorded during the respective months of August and November. The low content may be due to utilization of the nutrient by phytoplankton (Kaul *et al.*, 1980). For site-3(tap) the value was minimum during the month of December and maximum during the month of August. The higher values in summer may be either due to regeneration of phosphate from the decaying of plants and animal remains or increased temperature resulting due to death and decomposition of living biota (Bhat and yousuf, 2004). Similar observations were recorded by Simpi *et al.* (2011).

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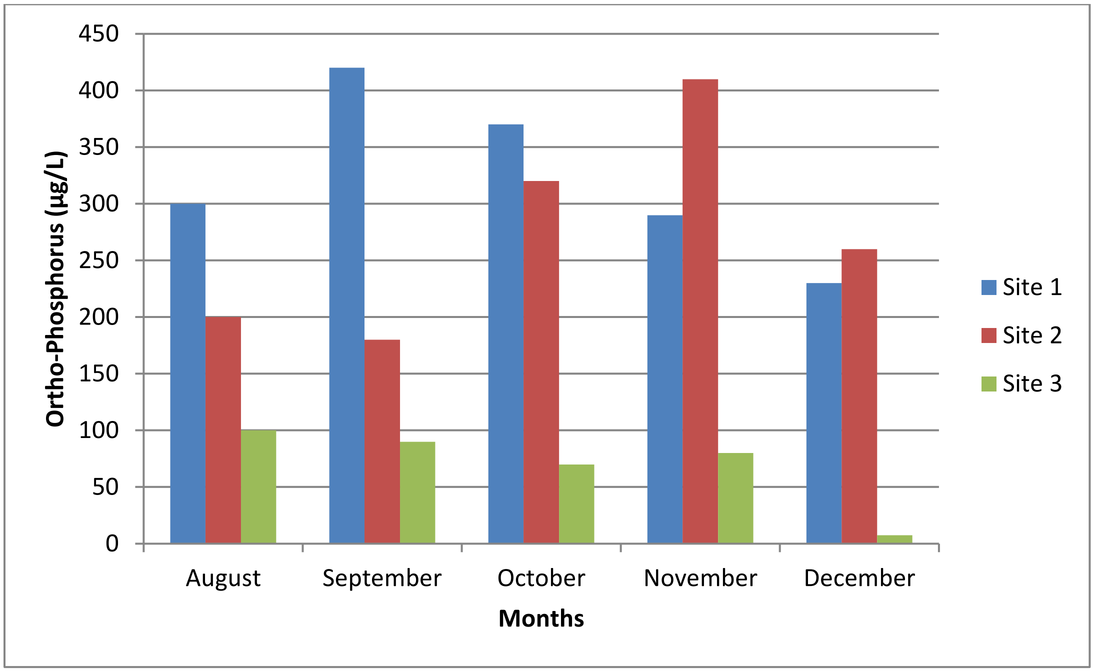


**Fig 11a: Monthly variation in Ortho-Phosphorus (µg/L) at different sites of Khrew during alternative months from August – December, 2017.**

**Table: Comparison of water quality with different standards.**

| Parameter | Site-1 (mean) | Site-2 (mean) | Site-3 (mean) | WHO Standards (2008) | | IS (2012) | |
|---|---|---|---|---|---|---|---|
| | | | | Min. Conc. Acceptable | Max. Conc. Acceptable | Acceptable Limit | Permissible Limit |
| **Temperature (C°)** | 13.2 | 14 | 14.4 | - | 28 | - | - |
| **pH** | 7.43 | 7.03 | 7.59 | 7.0-8.5 | 6.5-9.2 | 6.5-8.5 | No relaxation |
| **Electrical Conductivity (*µS/cm*)** | 517 | 543.4 | 514 | 750 | 1500 | - | - |
| **DO (mg/L)** | 4.88 | 5.52 | 5.38 | >4 | - | >4 | - |
| **Free $CO_2$ (*mg/L*)** | 12.4 | 10.06 | 13.8 | - | - | - | - |
| **Chloride (*mg/L*)** | 18.76 | 21.05 | 16.66 | 200 | 600 | 250 | 1000 |
| **Total Alkalinity (*mg/L*)** | 57.82 | 56.72 | 46.4 | - | 250 | 200 | 600 |
| **Total Hardness (*mg/L*)** | 123.2 | 120 | 102.4 | 100 | 500 | 200 | 600 |

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 4, No. 1, April : 2023

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Calcium Hardness (*mg/L*)** | 73.92 | 66.63 | 56.28 | 75 | 200 | 75 | 200 |
| **Magnesium Hardness (*mg/L*)** | 49.28 | 53.64 | 46.12 | 50 | 150 | 30 | 100 |
| **Ortho-phosphorus (*µg/L*)** | 322 or 0.322 mg/L | 274 or 0.274 mg/L | 80 or 0.08 mg/L | - | - | - | - |

*****1 mg/L = $10^3$(µg/L).
*IS: Indian Standard.
*WHO: World Health Organization.

Conclusion:
The functioning of an aquatic ecosystem and its stability to support life forms depends, to a great extent, on the physico-chemical characteristics of its water. The study of physical and chemical characteristics of water provides a considerable insight into the quality of water present in rivers, lakes, ponds, and groundwater. The water quality is directly related to health and is important for determination of water utility. Assessment of water quality is a critical factor for assessment of pollution levels

The study has provided information on the quality of spring water, stream water and tap water (Drinking water) of Khrew. After the careful study of analysis, interpretation and discussions of the numerical data following conclusions have been drawn:
The water temperature ranged from 12°C to 15°C at site-1 (Spring water), 10°C to 17°C at site-2 (stream water), and 11°C to 16°C at site-3 (Tap water), within permissible limits as recommended by World Health Organization standards, 2008 and Indian standards Specification for Drinking water, Second Revision, 2012).The water pH ranged from 7.32 – 7.65 at site-1 (spring water), 6.50 – 7.45 at site-2 (Stream water) and 7.26 – 7.90 at site-3 (Tap water), within the permissible limits as recommended by World Health Organization standards, 2008.The DO ranged from 4 mg/L – 6 mg/L at site-1 (spring), 4.6 mg/L – 6.6 mg/L at site-2 (stream) and 4.8 mg/L – 5.9 mg/L at site-3 (Tap water), within permissible limits as recommended by World Health Organization Standards, 2008 and IS, 2012. Maximum DO was found in stream and minimum was found in spring during the present study.The EC, free $CO_2$, chloride, total alkalinity, total hardness, magnesium hardness, calcium hardness and ortho-phosphorus were also within permissible limits for all the three sites analyzed, as recommended by world Health Organization standards, 2008 and Indian Standards Specification for Drinking water, Second Revision, 2012.The study revealed that all the parameters were within permissible limits at all the three sites as recommended by WHO, 2008 and IS, 2012). The present study also shows fluctuations in pH values that may be due to low rates of decomposition and good amount of calcium carbonates and magnesium in the area. The fluctuations in EC may be due to the contamination from domestic sewage.Thus, it may be concluded that the water resources at Khrew, with respect to spring and tap water are not polluted and are safe for drinking, domestic purposes and irrigational use. However, the presence of polythene bags, paper, plastic bottles and other wastes from local shops affects the water quality of stream that flows through main town of Khrew. The water from this stream is used for irrigation of local paddy fields. This polluted water when reaches the paddy fields alters the quality of soil. This problem can be controlled by collecting the plastic bottles, polythene and other wastes in dustbins instead of throwing them in stream. Another solution for this problem is screening of water before it reaches the paddy fields.It is also recommended that the water

resources of Khrew should be properly utilized for various purposes and also some measures should be taken for maintaining their future health as these water resources face a great threat from cement factories present in the area and increasing human pressure.

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