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Effect of Industrialization on Groundwater Quality, Miraj-Kupwad MIDC, Maharashtra State, India

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Miraj-Kupwad MIDC is hub of various industries, like food processing, starch, foundries, etc. A servey of groundwater samples from five sites in MIDC area was analyzed for pH, electrical conductivity, turbidity, total alkalinity, dissolved oxygen, biological oxygen demand, total hardness, chemical oxygen demand, sulphate, phosphate, chloride, nitrate, fluoride, lead, arsenic and chromium parameters as per APHA procedures. The obtained results were compared with Indian drinking standards and it was observed that parameters, like turbidity, alkalinity, hardness, sulphate, nitrates, chlorides, fluoride, lead, chromium and arsenic exceeded the acceptable limit while all sites showed phosphate values within limit. The presence of these contaminants in water samples indicate contamination of groundwater in study area. It may be due to improper effluent disposal and other anthropogenic activities.

KEYWORDS

Groundwater quality, Miraj-Kupwad MIDC, Seasonal variation

1. INTRODUCTION

Water is one of the vital components of living forms on Earth. In India, about 30% of the urban population and over 90% of rural population rely on groundwater for residential and drinking needs [1]. India is a developing country, which leads to development of various industries, like metal processing, fertilizers, food processing, pharmaceuticals and other industries, like dye, paints, plastic, detergents, etc. Industrial development requires availability and use of tremendous amounts of water, which results in generation of huge amounts of wastewater. Improper sewage management, industrial wastewater and dumping of solid waste result in contamination of groundwater. Groundwater contamination is typically irreversible, meaning that it is challenging to return aquifer's original water quality once it has been poisoned. Groundwater that has been too mineralized loses quality and develops an unpleasant flavour, odour and excessive hardness. As a result, it is always preferable to safeguard groundwater upfront rather than relying on technology to purify tainted water down the road [2].

The Sangli-Miraj-Kupwad urban complex is primarily where district's industrial development has occurred. Sangli district has a total of eleven MIDCs, with Miraj-Kupwad MIDC industrial area being one of the oldest in the district. The Miraj MIDC industrial area has 166.48 ha of land with no effluent collection system and sewerage line available. Kupwad industrial area consists of foundries and fabric-possessing industries with 223.63 ha area with no effluent collection system, sewerage line and sewerage treatment plant. The construction of a common effluent treatment plant with a 1 MLD capacity, known as M/s. Krishna Vally Pvt. Ltd., MIDC Kupwad, tal Miraj, district Sangli, has not yet been completed due to five pending court cases involving neighbouring people. Additionally, absent from the MIDC region is a facility for disposal of common hazardous waste. Vast industrial growth results in various environmental issues. Studies show that bore water from Kupwad industrial area show excessive amounts of total dissolved solids (TDS), sodium, cadmium, chloride, nitrate and dissolved solids, which make water unfit for drinking [3]. Effluent from eight textile industries from Ichalakaranji shows high amount of cadmium, iron, copper, chromium, lead, nickel, zinc and arsenic. High amount of all these heavy metals were observed in samples obtained from Panchaganga river where effluent mixes in the river [3].

A study also showed that the water in this industrial region is highly polluted with high TDS and hardness

Table 1. *Sample locations of different groundwater sampling areas used in the present study*

Site number	Name	Location
Site 1- S1	Dug well near Chougule mala- near Miraj MIDC	74.64743 N, 16.85544 E
Site 2- S2	Bore well in Gulmohar colony(near RenukaMandir)- near Miraj MIDC	74.63152 N, 16.84508 E
Site 3- S3	Bore well in Waghmode Nagar (in front of Biroba Mandir)-near Kupwad MIDC	74.6276 N, 16.86415 E
Site 4- S4	Dug well near RTO-near Kupwad MIDC	74.63934 N, 16.870445 E
Site 5- S5	Bore well in front of Mohite clinic-near Kupwad MIDC	74.6302 N, 16.883842 E

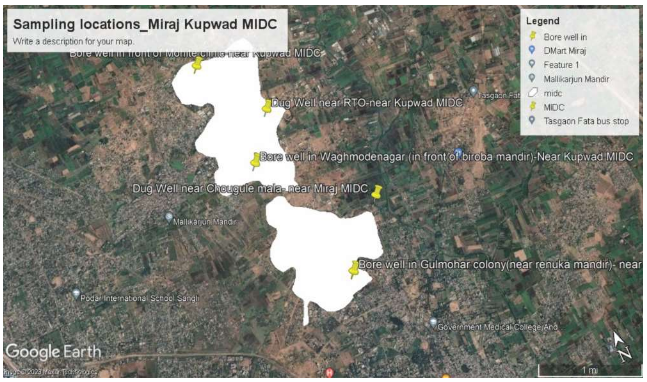

Figure 1. *Sampling location of Miraj-Kapwad MIDC*

values. Some samples showed high MPN values, making water not suitable for drinking [4]. Assessment of the water quality of Krishna river from Sangli showed presence of contaminants in river as compared to other water sources; also, the study observed the spread of diseases, like cholera, typhoid, diarrhoea, jaundice, gastro infections, etc., in the community nearby Krishna river [5,6]. The Sheri Nala basin of Sangli's groundwater pollution study revealed total hardness, total dissolved solids and chloride values higher than standard values and the primary cause was industrial pollution in Madhavnagar and Kupwad sub-basins. Additionally, it was noted that 9% of households experienced cholera, 13% experienced jaundice, 64% experienced gastroenteritis and 14% experienced typhoid [7]. Groundwater (bore well and dug well) in the region near Sangli Miraj Kupwad, MIDC, exceeded BIS standard limits [8]. Groundwater quality of Sangli-Miraj-Kupwad industrial area showed exceeding levels of nitrate, sodium, chloride, nitrate, dissolved solids, heavy metals (including mercury, lead, cadmium and arsenic) and other contaminants higher than the permitted limits. Correlation data demonstrate a strong association between electrical conductivity (EC) and TDS; dissolved solids (DS), magnesium and chloride. The mathematical relationship between EC and TDS, TDS and chloride and iron and mercury was used to illustrate the regression procedure [3]. To date enough attention has not been given to study the diversity of water sources in the rural area. Understanding its physico-chemical properties alongwith species reveal necessary facts required for management of ecosystem and habitat.

2. MATERIAL AND METHOD

Area selected for study was Miraj-Kupawad industrial area which is situated at Miraj tehsil of Sangli district, Maharashtra state, India. Its geographical coordinates are 16°52'0" N, 74°34'0" E.

2.1 Sampling locations and chemical analysis

To analyse several physico-chemical parameters for the 2019–2020 academic year, groundwater samples were taken from five distinct places during summer (February to May), rainy (June to September) and winter (October to January) seasons (Figure 1 and Table 1). The samples were collected every month of each quarter. After 10 min of pumping, the samples were collected in 1 L sterilised screw-cap polyethylene bottles and then examined in laboratory. The samples that were taken from the study locations were tagged correctly. Temperature was measured on-site. Standard methods were used for the determination of various parameters, such as pH was measured using pH meter, electrical conductivity was measured using Elico–digital conductivity meter CM 180 digital, turbidity was measured using digital turbidity meter (nephelometer) model no. EQ 813. Methyl orange and phenolphthalein were used as indicators in visual titration method to calculate total alkalinity. Using EBT indicator, the EDTA titrimetric method was used to measure calcium and total hardness. The most common method of identifying chloride ions is to titrate the samples against a standard $AgNO_3$ solution while employing potassium chromate as an indicator. Water samples' sulphate, phosphate, nitrate and flouride levels were calculated using Labtronics LT-39 spectrophotometer. Using flame photometer 128 from Systronics (India) Limited, sodium and potassium were calculated. Atomic absorption spectrophotometer was used to

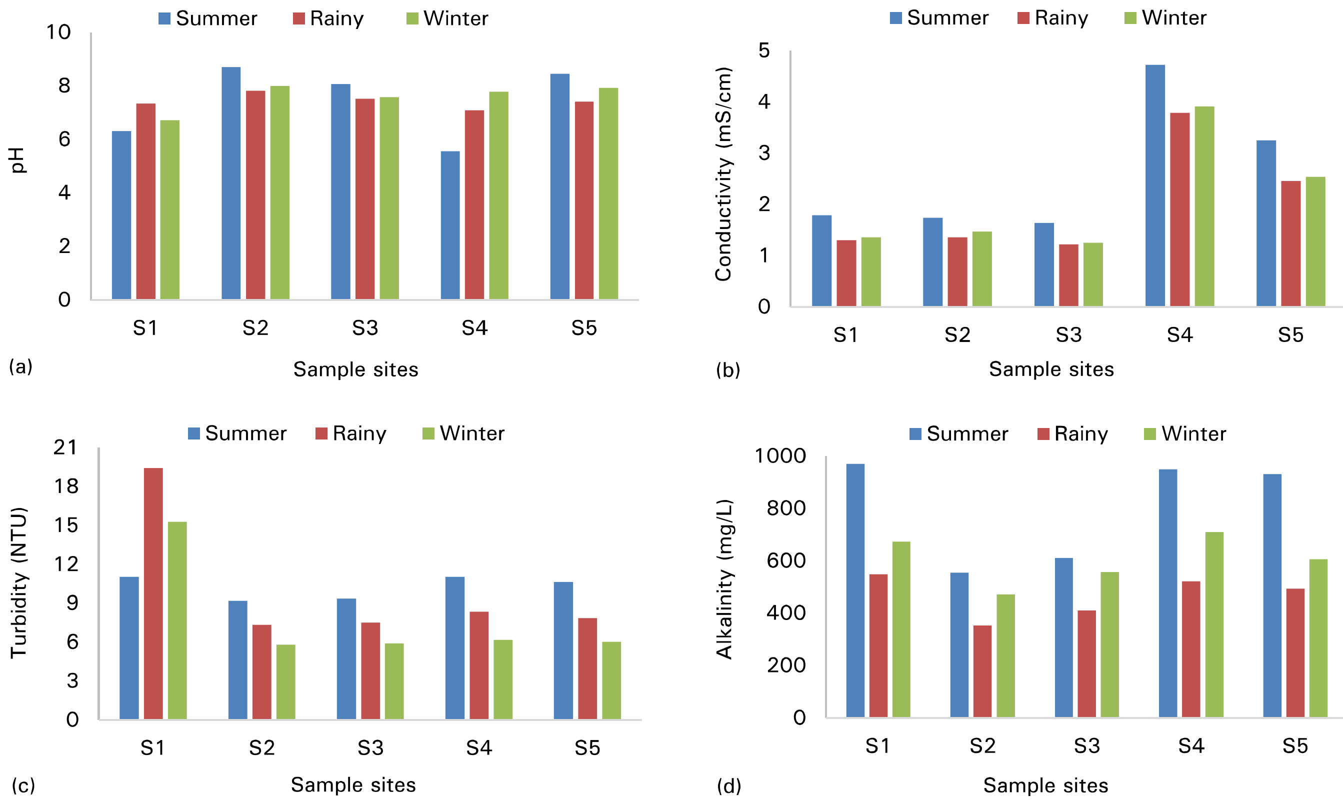

Figure 2. *Results of (a) pH, (b) elecrical conductivity, (c) tubidity and (d) total alkalinity in water samples of the study area*

analyse heavy metals, such as arsenic, iron, chromium and lead.

3. RESULT AND DISCUSSION

3.1 Phsico-chemical analysis

Lowest pH value of 5.5 was observed in summer on site S4. High decomposition processes in the summer cause high pH levels. A similar outcome was seen in the small Mahi river and the Yammuna river in Faridabad [9]. Highest pH value of 8.46 was observed in summer at site 5. The pH value observed was higher than the desirable limit which ranges from 5.56-8.7. The maximum value was observed at S2 and minimum value observed value at S4 in the limit from 5.56. The safe limit of pH lies between 6.5-8.5. The slightly acidic and alkaline nature of water at some sites indicates impact of industrial effluent (Figure 2a). EC values range from 1.22-4.72 ms/cm. Lowest value was observed at site S3 in monsoon and highest value was observed at site S4 in summer. The suggested EC value for drinking water is 1400 ms/cm. The samples that showed values above the safe limit levels were may be a result of anthropogenic activity, mineral dissolution or regional geochemical processes (Figure 2b) [10]. Turbidity values observed were in range from 5.92-19.43 NTU. All sampling sites exceeded permissible limit of turbidity, which indicates presences of high bacteria level, pathogens or particles that can shelter harmful organisms (Figure 2c) [11]. Total alkalinity observed were from 353 mg/L in rainy season at S2 to 970 mg/L in summer at S1. It was observed that all sites exceeded acceptable limit of total alkalinity. Plants and other living things die and decompose throughout the summer as a result of the well's lower water level. Therefore, as plants decompose, CO_2 is released, adding carbonate and bicarbonate to the water; this may also be one of the causes for the rise in alkalinity value. Similar results were seen in Dharwad, Karnataka's ponds and lakes (Figure 2d) [9].

Dissolved oxygen (DO) values observed ranged from 1.9 mg/L in summer at S5 to 10.82 mg/L in rainy season at S1. The lowest DO at site 5 may be due to increased amount of organic matter from industrial waste which need oxygen for decomposition (Figure 3a). Biological oxygen demand (BOD) values were observed between 183-382 mg/L with lowest value at site S3 during rainy season and highest at site S5 during summer season. High amount of BOD values at all sampling sites is a sign of high level of organic pollutants present in water samples. The maximum allowed

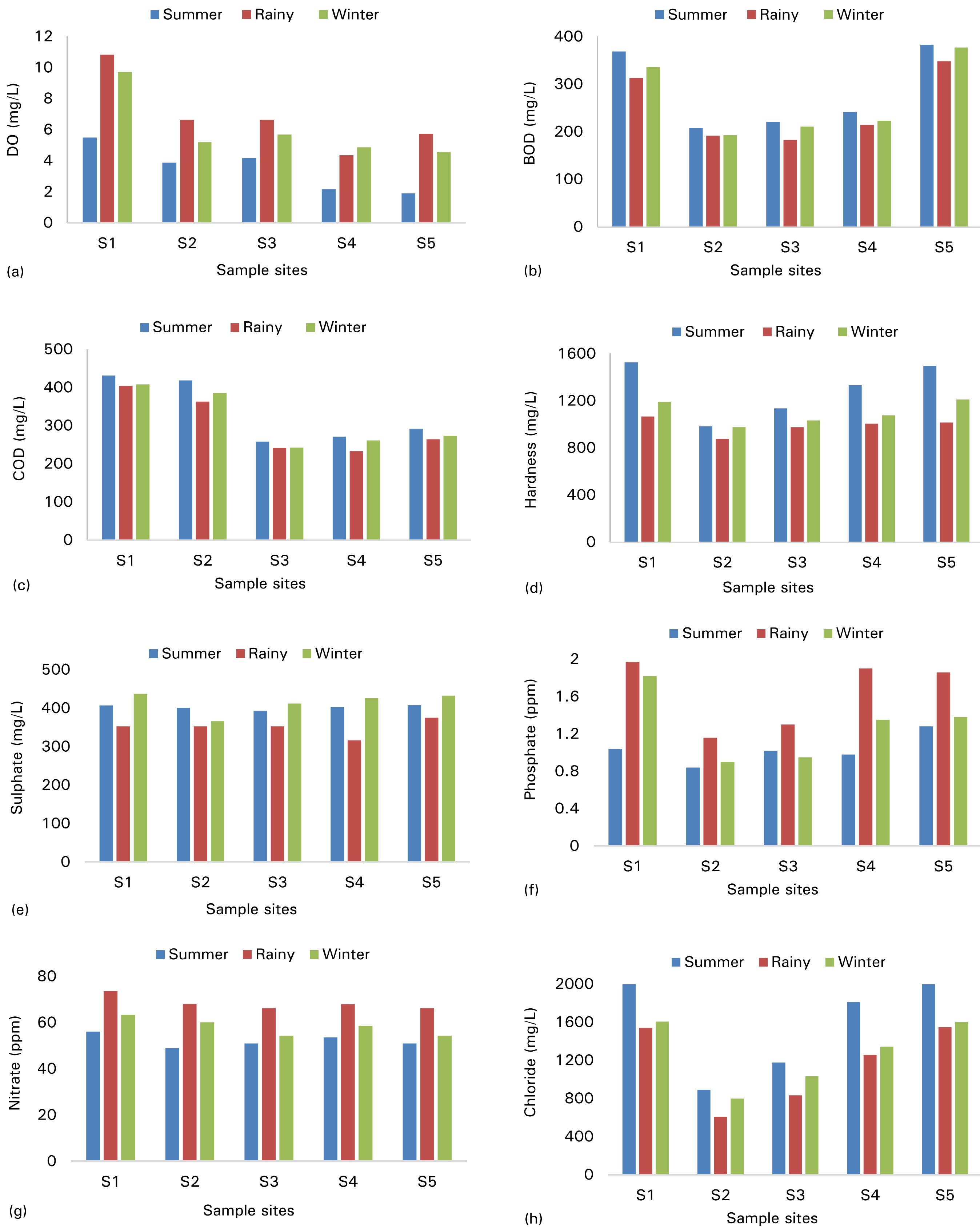

Figure 3. *Graphical representation of water quality parameters of the study area during different seasons*

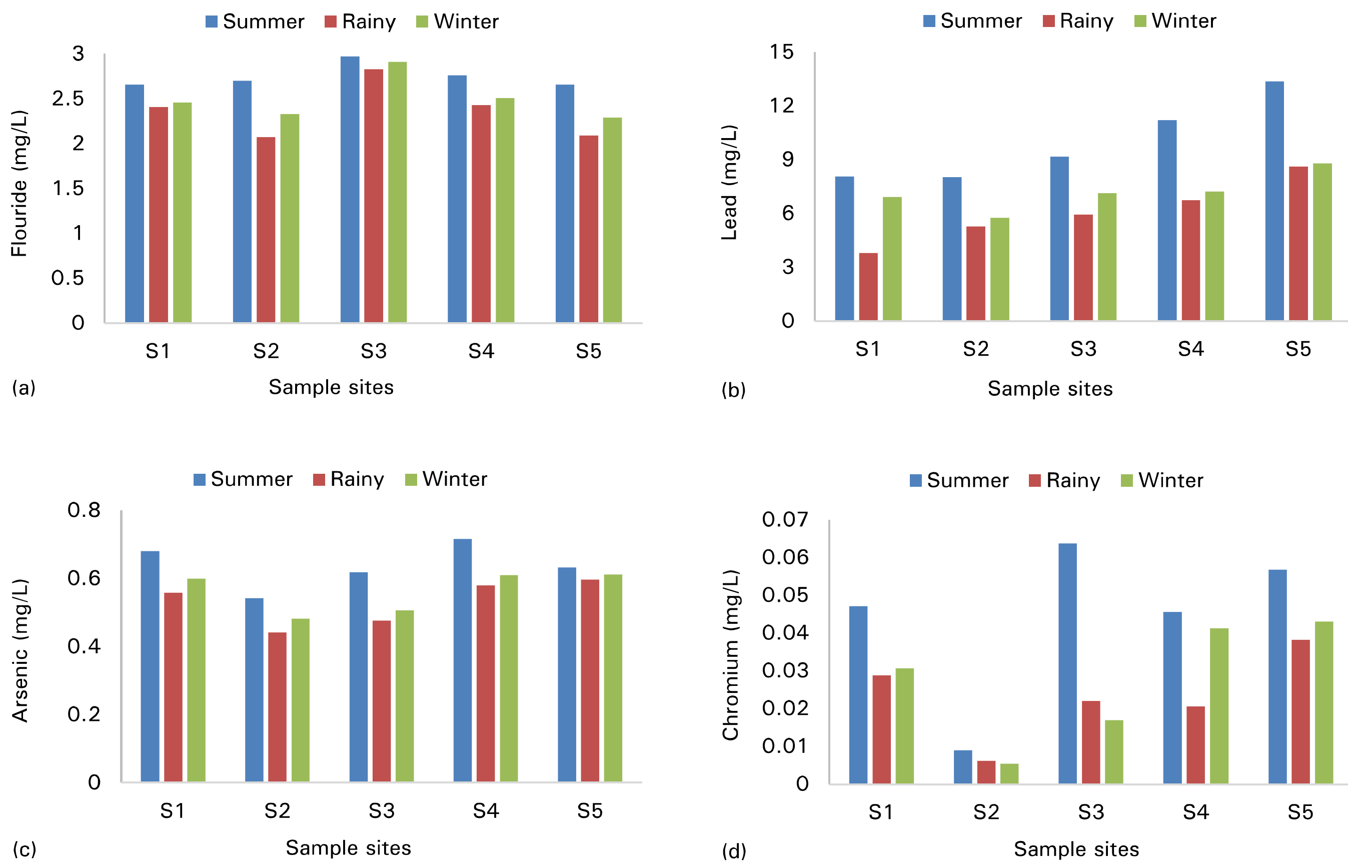

Figure 4. *Results of (a) flouride, (b) lead, (c) arsenic and (d) chromium in water samples of the study area*

BOD for drinking water is 10 mg/L (Figure 3b) [12]. Chemical oxygen demand (COD) values were observed from 233 mg/L at site S4 in rainy season to 461 mg/L at site S5 in summer season, indicating the values of COD are much higher than allowed limit of COD; these values indicate contamination of water with industrial effluent (Figure 3c). The results are far higher than what is predicted for drinkable water of good quality. Indices of organic contamination include COD and BOD. Drinking water supplies shouldn't have COD more than 2.5 mg/L and potable water with COD content of more than 7.5 mg/L is considered of low quality [12].

Calcium and magnesium ions, which are generally formed by the breakdown of carbonated rock, are the principal regulators of groundwater hardness [13]. Total hardness values observed ranged from 876-1528 mg/L with highest at site S2 during rainy and lowest at S1 during summer season (Figure 3d). Acceptable limit of hardness is 200 mg/L and permissible limit in absence of alternative source is 600 mg/L. Total hardness at all sites fot all seasons exceeded the acceptable as well as permissible limit. So, water from study area is unfit for drinking purposes as it lies in very hard water category. Sulphate values observed varied from 316 mg/L (site S4) to 437 mg/L (site S1). The acceptable limit for sulphate is 200 mg/L. At all sites the values of sulphate exceeded the acceptable limit (Figure 3e). Its concentration tends to rise with the discharge of home sewage and industrial waste in the water body [14]. Observed phosphate values ranged from 0.84 ppm at site S2 in summer to 1.97 ppm at S1 in rainy season (Figure 3f). WHO recommended limit of phosphate is 5 mg/L, which shows all samples has phosphate within the WHO limit [14]. Nitrate values observed in study area ranged from 48-73 ppm with acceptable limit of 45 mg/L, this shows all sites' samples exceeded acceptable limit for nitrate (Figure 3g). High level of nitrate is a result of anthropogenic activities which discharges nitrate that leaches from surface to underlying aquifers resulting in high nitrate content in waterbodies [15]. Chloride values observed inthe study ranged from 609 mg/L at site S2 in rainy to 2145 mg/L at site S5 in summer. At all sites, chloride values exceeded the acceptable limit of 250 mg/L (Figure 3h). Both natural and man-made causes, such as run-off containing salts, usage of inorganic fertilizers, landfill leachates, septic tank wastes, animal feeds, industrial effluents and irrigation drainage, can result in high chloride levels in groundwater[16].

Observed values of fluoride varied from 2.07 mg/L at site S2 in rainy season to 2.97 mg/L site S3 in summer (Figure 4a). The acceptable limit of fluoride is 1 mg/L, therefore fluoride concentration at all sites exceeded the acceptable limit. An excessive amount of fluoride in the water can seriously harm the teeth and bones of humans, leading to disorders including dental fluorosis, muscular fluorosis and skeletal fluorosis that exhibit symptoms of disintegration and decay [17]. Lead values observed were between 3.79 mg/L at site S1 in rainy season and 13.34 mg/L at site S5 in summer with acceptable limit of 0.01 mg/L (Figure 4b). Amount of lead in natural water increases mainly because of anthropogenic activities. The presence of lead in natural water suggests that groundwater contamination was caused by industrialization and urbanization [18]. The observed values of arsenic ranged from 0.4-0.7 mg/L whereas acceptable limit for arsenic is 0.01 mg/L. The result shows that arsenic exceeded at all sites (Figure 4c). The values of chromium observed ranged 0.005-0.06 mg/L (Figure 4d). Chromium values at sites S5 and S3 exceeded acceptable limit of 0.05 mg/L in summer season. High content of chromium maybe due to various anthropogenic activities, industrial effluents, tanneries, old plumbing and household sewages [19].

4. CONCLUSION

It was observed that groundwater samples from Miraj-Kupwad MIDC show a high level of contamination of fluoride, sulphate, nitrate, chloride, lead, chromium, turbidity and hardness. If such highly contaminated water is used for daily activities, it may result in serious health issues. Excessive addition of these contaminates is mainly due to anthropogenic activities, involving urbanization and industrialization. Insufficient effluent treatment plants and inadequate treatment facilities at industries lead to increased industrial effluents which, in turn, contaminate the aquifers. The study area requires proper disposal of effluents. It will help to save these natural water sources and future water scarcity issues.

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