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Analysis of Groundwater Quality of Borough X (10), Kolkata for assessment of Pre-Monsoon and Post Monsoon Variation

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Abstract— ***The evaluation of groundwater quality is the key towards ensuring and monitoring the nature of groundwater. Hence, it turns out to be essential to direct a legitimate and detailed evaluation for the maintenance of groundwater quality, and for further improvement in the water quality of the aquifer. An attempt has been made to understand the changes in the physiochemical characteristics of groundwater for pre-monsoon and post-monsoon period of Borough X (10) of Kolkata, the capital of West Bengal. The study area covers nearly 15.716 km^2 region of the city, serving a population of nearly 389461, which is nearly 8.66 % of the total population of the city. The groundwater quality of the region is under constant threat primarily to several anthropogenic activities which has steadily increased over time. The analysis of physiochemical parameters such as pH, Total Dissolved Solids, Electrical Conductivity, Turbidity, Chloride, Total Alkalinity, Total Hardness, Nitrate, Iron, Arsenic, and Fluoride provides a detailed outlook into the several parameters involved. The Borough consists of 12 wards of which 20 samples were collected from each ward pre-monsoon on March, 2018 and post-monsoon on September, 2018 and a comparative analysis was executed. The study shows a slight but noticeable improvement in the groundwater quality of the region post the monsoon period. This phenomenon could be noted primarily due to the dilution of the groundwater with rainwater which had been received by the aquifer in the monsoon season via infiltration.***

Keywords— Groundwater Assessment, Water Quality, Kolkata, Comparative Analysis, Physiochemical Parameters

I. INTRODUCTION

Groundwater is a valuable asset that is fundamental for human wellbeing, socio-economic advancement, and proper functioning of several ecosystems. [1]. Healthy aquifers convey imperative ecological services, as for example the filtration of infiltrated water and the effective storage of high-quality water over a significant amount of time in relatively larger quantities. [2]. Owing to the rapid increase in population and in turn the increase of anthropological activities, the quality of groundwater is deteriorating gradually. Transient changes at the initial point and constitution of the recharged water, hydro-geological and human activities may cause periodical changes in groundwater quality. Determining the groundwater quality is essential before its utilization for different purposes, for example, drinking, horticultural, recreational or industrial use. Thus, monitoring of groundwater quality has turned out to be imperative. The present study was performed before and after the advent of monsoon to facilitate the comparative analysis of the change in the different water quality parameters notably pH, Total Dissolved Solids, Electrical Conductivity, Turbidity, Chloride, Total Alkalinity, Total Hardness, Nitrate, Iron, Arsenic, and Fluoride contents of the study area. This analysis determines the effect of monsoon and it's influence in the self-remediation capability of the underlaying groundwater aquifer.

II. STUDY AREA

Kolkata lies on the Eastern Bank of the River Hooghly. The tail end of the river flows by the western side of Kolkata, before reaching the Bay of Bengal around 180 Km. downstream from the city. The city has a population density of nearly 24.760 persons/ Km^2, positioning itself as the seventh largest city in India in terms of population and area. The city is nearly 1480 Km^2 in area of which 205 Km^2 area comes under the responsibility of the Kolkata Municipal Corporation. The Kolkata Municipal Corporation or KMC is responsible for the administrative and civic infrastructure of the city. The government body has assorted the city into 16 Boroughs with further divisions as wards for the ease of operation. The study area involves Borough X (10), under the Kolkata Municipal Area, comprising of 12 wards. This area was specifically chosen as the area is rapidly increasing in population, accounting for nearly 8.66 % of the total population of the city. The maximum

Table I - Identification of Study Area

Ward no.	Area (Km^2)	Population
81	1.27	41501
89	0.70	22304
91	1.08	38450
92	1.57	36450
93	1.87	44364
94	1.67	27469
95	1.01	26737
96	1.13	31033
97	1.93	37199
98	1.16	31708
99	0.91	26739
100	1.41	25507

temperature of the study area rises during the summer months which ranges from May-June varies from 24 - 42C and the minimum temperature falls whilst in the winter months ranging from December - January varying from 8 - 26C on an average. The climate is mostly humid varying from 85 - 65% during the months of summer. From June to September is usually the monsoon period having an average rainfall of 158 cm.

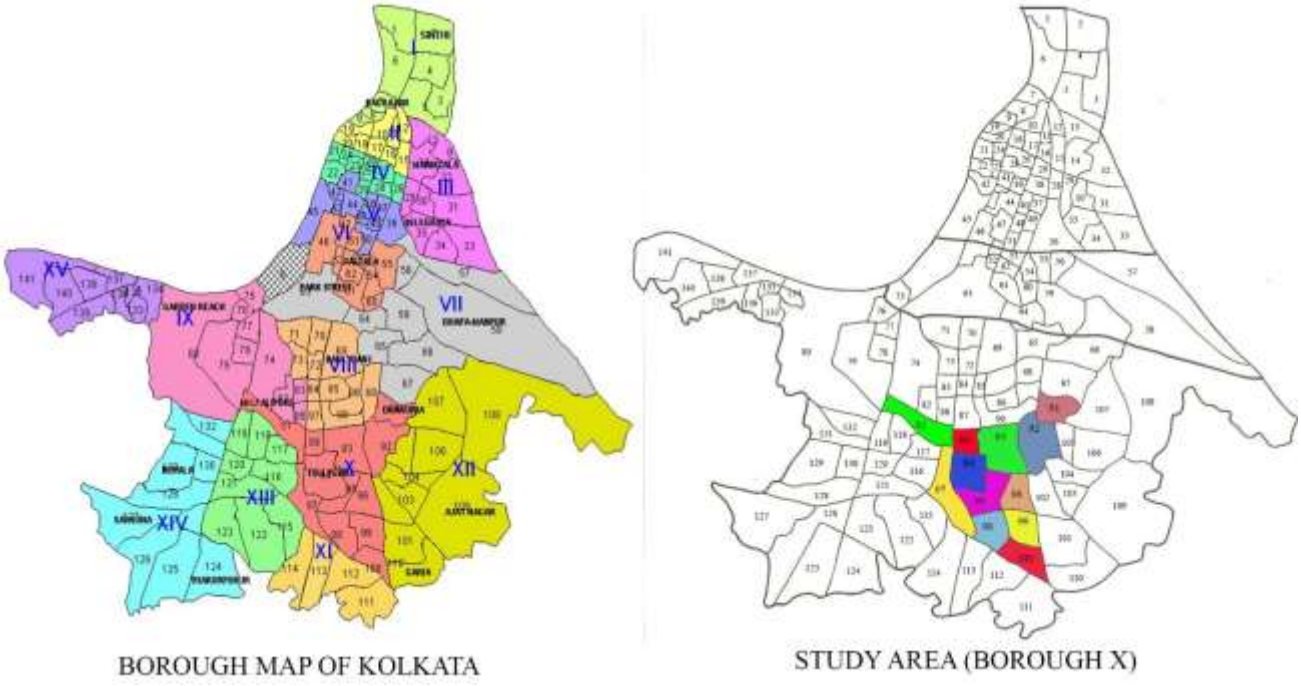

Figure 1 - Borough Map (Left) and Study Area with Ward Map (Right)

III. MATERIALS AND METHODS

For the analysis of water quality of water quality, the Wards under Borough X (10) were identified from the Kolkata Municipal Corporation. Each ward was further subjected to 20 sampling points which were selected so that the points were scattered all over the study area and not conjugated to any specific region. The samples of groundwater were collected from tube wells not less than 70 m as the principal productive freshwater aquifer ranges at a depth of 60m to 180m in the region. The water from the 20 sampling points were collected twice, first on March, 2018 (Pre-monsoon) and secondly on September, 2018 (Post-Monsoon). The samples were collected on clean dry plastic water bottles so as to avoid any kind of alien contamination or dilution of the collected water samples. The collected water samples were immediately tested in the laboratory to prevent any physiochemical changes. The error correction due to time delay has hence been considered negligible for the study. The procedures for determining the parameters have been performed as per standard testing methods laid out by American Public Health Association [3] and Bureau of Indian Standards [4].

Table II - List of parameters and their tests performed

Parameter	Procedure
pH	IS 3025 (Part 11)
Total Dissolved Solids (TDS)	IS 3025 (Part 16)
Electrical Conductivity (EC)	APHA (2510 A.)
Turbidity	IS 3025 (Part 10)
Chloride (as cl)	APHA (4500 Cl B.)
Total Alkalinity	IS 3025 (Part 23)
Total Hardness	IS 3025 (Part 21)
Nitrate (as NO3)	IS 3025 (Part 34)
Iron (Fe)	IS 3025 (Part 34)
Arsenic (As)	APHA (3500 As C.)
Fluoride (F)	APHA (4500 F B.)

IV. RESULTS AND DISCUSSION

The two datasets were prepared according to the data results obtained from the testing of the collected water samples. The datasets were distinguished according to the parameters and graphical representation was plotted contesting the parameter to time period i.e. pre-monsoon or post-monsoon. This clarifies the definitive change in water quality and eases the comparative analysis of the different parameters in accordance to the period of sample collection.

pH: pH is a parameter utilized for the determination of the acidity or alkalinity of the water, it is the measure of hydrogen-ion concentration in the water samples. For the current analysis, the pH values of the water samples range between 7.3 to 8.57 in the post-monsoon period and from 7.09 to 8.03 in the pre-monsoon phase.

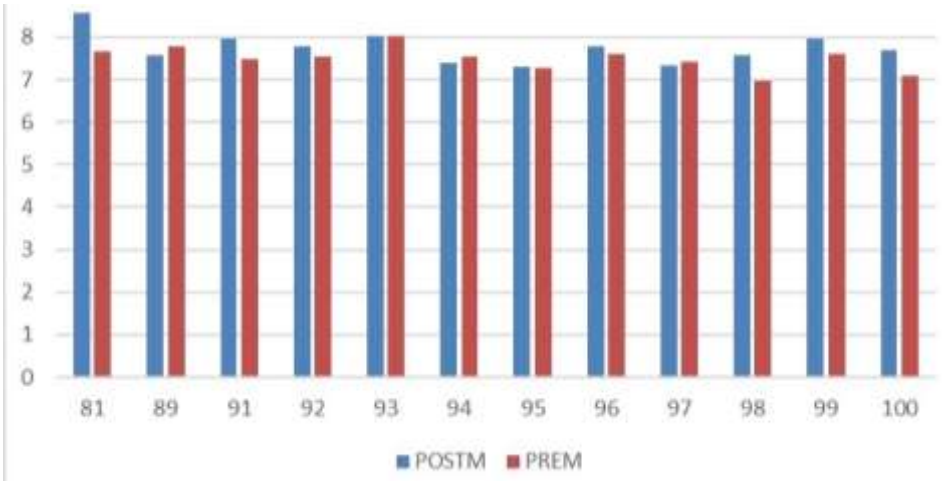

Figure 2 - Graphical comparison of pH values for post-monsoon and pre-monsoon periods

Total Dissolved Solids (TDS): Total dissolved solids (TDS) in water are basically composed of solid substances that are dissolved in the water sample and pose various hazardous effects on human health. The collected water samples possess a TDS value ranging from 493.65 mg/l to 1402.3 mg/l for the Post-Monsoon period and from 569.1 mg/l to 1434.6 mg/l for the Post-Monsoon phase.

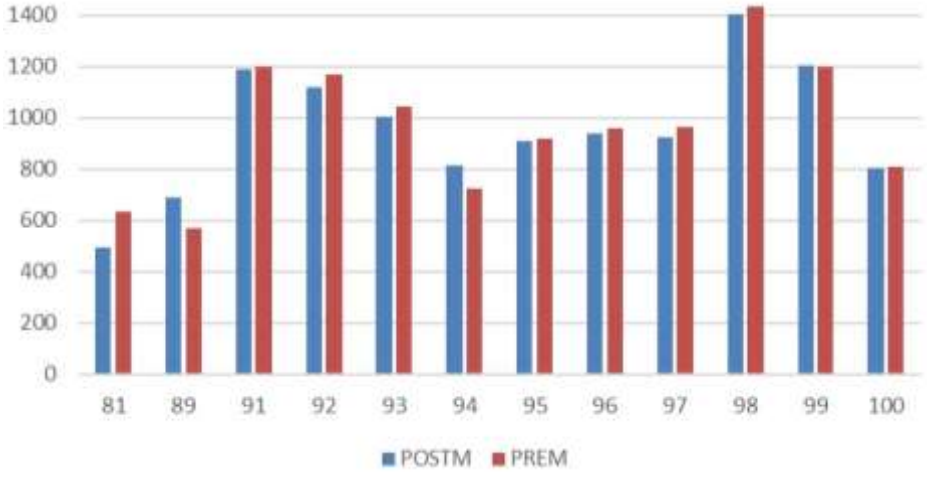

Figure 3 - Graphical comparison of TDS values for post-monsoon and pre-monsoon periods

Electrical Conductivity (EC): The electrical conductivity of a water sample or a solution is the capacity to conduct electric current and it depends upon the nature and the concentration of ionized salts, which depend on the ionic strength. In the current investigation maximum conductivity recorded during the post-monsoon period is 2551.45 µS/cm and the minimum conductivity recorded in the pre-monsoon period is 1036.54 µS/cm.

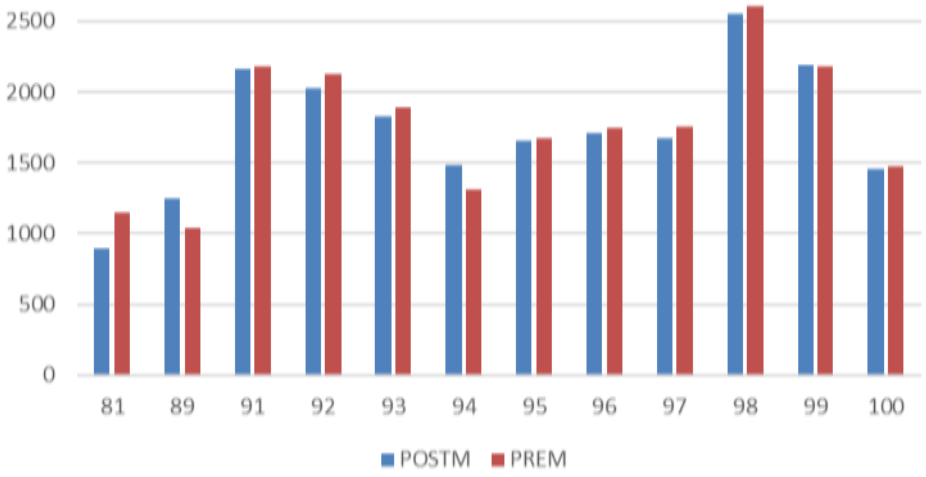

Figure 4 - Graphical comparison of EC values for post-monsoon and pre-monsoon periods

Turbidity: Turbidity is the quality of water that defines the cloudiness or fogginess of a water sample caused by suspended solids that are generally undetectable to the bare eye. For the current analysis, the turbidity of the water samples range between 1.356 to 2.69 in the post-monsoon period and from 1.317 to 2.6055 in the pre-monsoon phase. The data analysis shows the average pH value of the water samples during post-monsoon period is usually more than the pre-monsoon period.

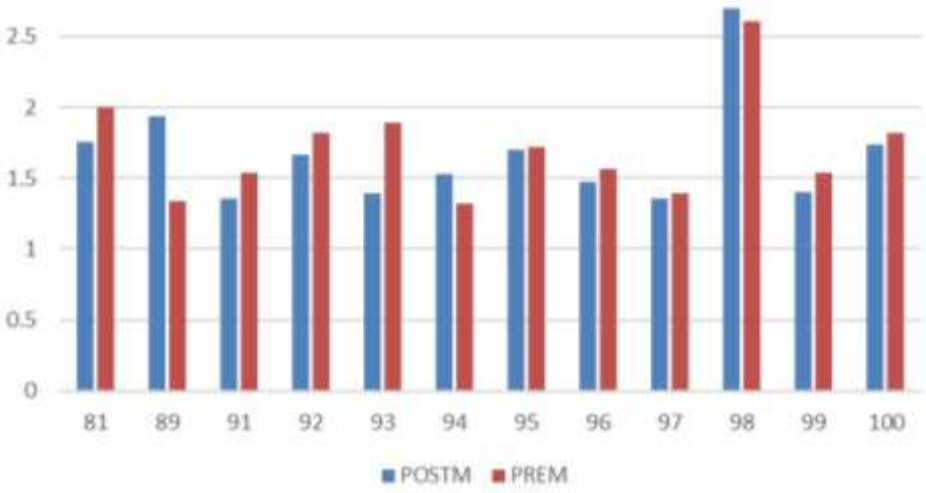

Figure 5 - Graphical comparison of turbidity values for post-monsoon and pre-monsoon periods

Chloride: Chloride as an anion occurs in natural waters in a wide range of concentrations. Chloride ions enters the water in solution form in underground aquifers. Natural spike in the chloride concentration of groundwater can occur during low flow periods, when the evaporation rate exceeds the infiltration rate. The current report shows chloride concentrations in a wide range of 196.5 mg/l to 680.25 mg/l in the post-monsoon period and from 163.8 mg/l to 696.0 mg/l in the pre-monsoon period.

Total Alkalinity: Alkalinity is the measure of buffering capacity of water. It generally is imparted by salts of bicarbonates, carbonates, phosphate, borax, nitrates, silicates etc., in sync with the hydroxyl ions in free states. [5]. In the present experimentation on the collected water samples the total alkalinity values show a range of 174.2 mg/l to 396.6 mg/l in the post-monsoon period and from 205.3 mg/l to 359.2 mg/l in the pre-monsoon period.

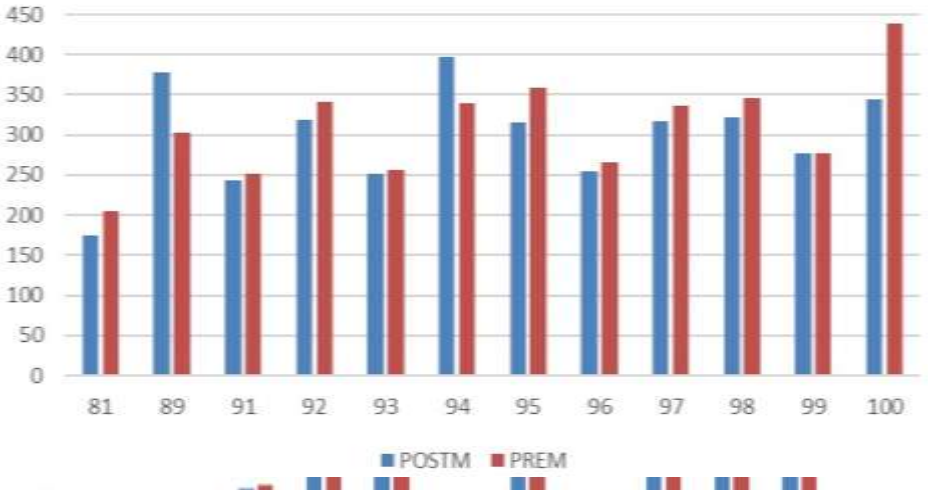

Figure 7 - Graphical comparison of total alkalinity values for post-monsoon and pre-monsoon periods

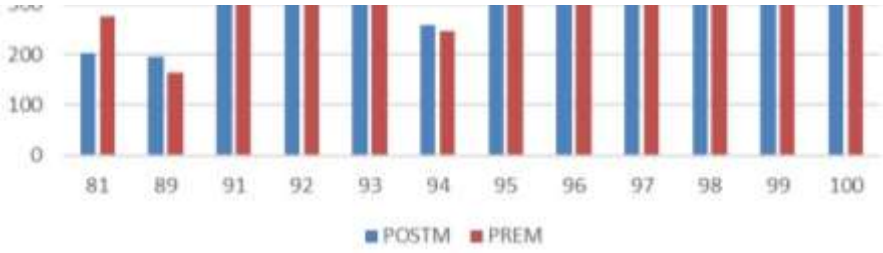

Figure 6 - Graphical comparison of chloride concentrations for post-monsoon and pre-monsoon periods

Total Hardness: The total hardness of water is considered to be the sum of concentrations of various alkaline earth metals cations. Hardness is usually governed by the concentrations of magnesium and calcium salts, which largely fuses with carbonates and bicarbonates giving water the temporary hardness. The water with concentrations of magnesium and calcium salts combining with chlorides, sulphates, and others anions cause permanent hardness. In the present experimentation on the collected water samples the total hardness values show a range of 262.9 mg/l to 736.4 mg/l in the post-monsoon period and from 426.8 mg/l to 744.0 mg/l in the pre-monsoon period.

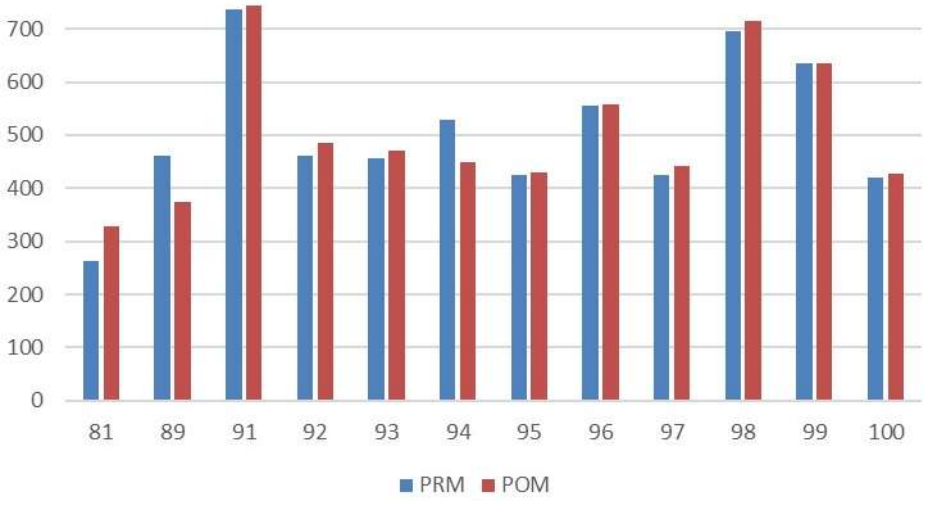

Figure 8 - Graphical comparison of total hardness values for post-monsoon and pre-monsoon periods

Arsenic: Arsenic contamination in groundwater is of major concern in West Bengal. Arsenic being carcinogenic in nature must be thoroughly and routinely analysed for the proper understanding of the aquifer characteristics of the region. The arsenic content in the water samples collected from the underlying aquifer in the post and pre monsoon period shows results below any detection level.

Nitrate: The presence of nitrates in groundwater happen due to the leaching of nitrate with the percolating water into the underlying aquifer. There were no detectable levels of nitrate in the water samples collected in pre-monsoon period nor in post-monsoon period.

Iron: Manganese (Mn) and Iron (Fe) and metals that usually occur naturally in various soils, rocks and minerals. In the underground aquifer, the groundwater comes in direct contact with these metal ores dissolving them and releasing their constituents which include Iron and Manganese. The current report shows chloride concentrations in a wide range of 0.5005 mg/l to 1.4965 mg/l in the post-monsoon period and from 0.8415 mg/l to 1.5525 mg/l in the pre-monsoon

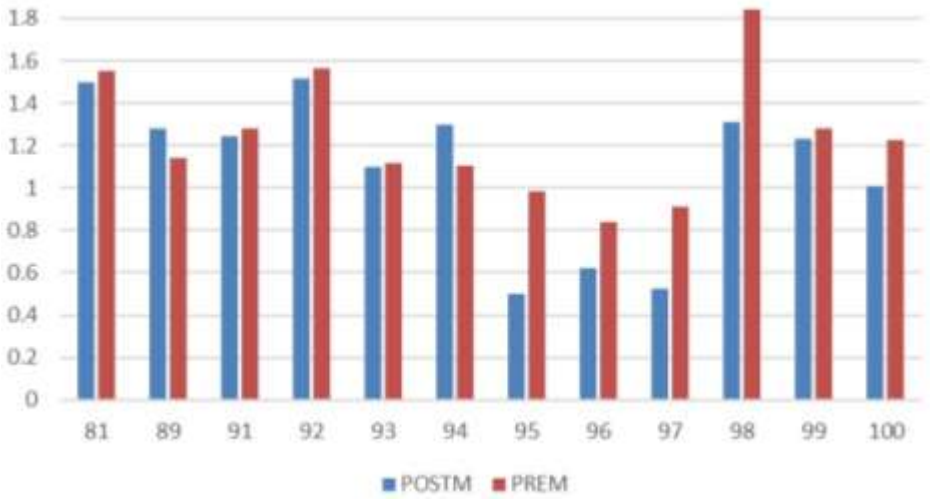

Figure 9 - Graphical comparison of iron concentrations for post-monsoon and pre-monsoon periods

period.

Fluoride: Fluoride is an ion of fluorine which associates with the halogen group. If the total concentration is low, approximately 1 mg/l, it has a significant mitigation effect on dental caries. However, continued consumption of fluoride in higher concentrations cause dental fluorosis and in high concentrations might even cause skeletal fluorosis. The current report shows fluoride concentrations are relatively low but in varied range of 0.236 mg/l to 0.565 mg/l in the post-monsoon period and from 0.251 mg/l to 0.578 mg/l in the pre-monsoon period.

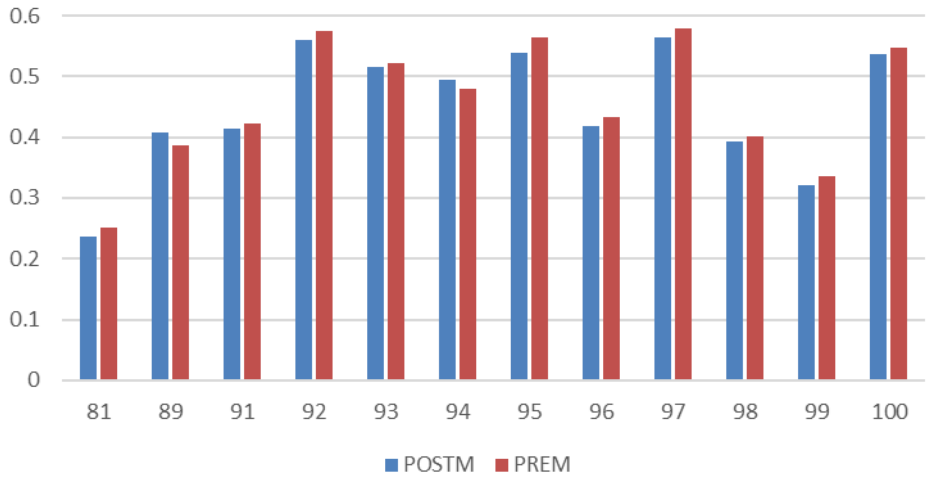

Figure 10 - Graphical comparison of fluoride concentrations for post-monsoon and pre-monsoon periods

V. CONCLUSION

The results show a wide array of parameter changes within the various wards of the borough in the post-monsoon and pre-monsoon periods. The data analysis shows the average pH value of the water samples during post-monsoon period is usually more than the pre-monsoon period. The reduction in values of TDS and turbidity during the post monsoon period shows even after the high rate of urbanisation in the region, precipitated water is infiltrating the soil cover to reach the underlying aquifer. Henceforth, reducing the concentrations of total dissolved solids and also the suspended solids in the groundwater. The increase in alkalinity and hardness values suggest that the infiltrated water entering the aquifer is being affected by several anthropogenic activities. The most common sources of iron and manganese in groundwater are naturally occurring, for example from weathering of iron and manganese bearing minerals and rocks. Industrial effluent, acid-mine drainage, sewage and landfill leachate may also contribute iron and manganese to local groundwater. The decrease in these parameters while in the post-monsoon period suggest a steady bordering soil for the aquifers, with the exception of ward no. 94 where the post-monsoon parameters are high. It shows that the aquifer is surrounded by soil rich in the minerals which are dissolved by infiltrating rainwater and are entering the groundwater in solution form. There were no detectable levels of nitrates in the water samples which suggest there is external pollution of biological interference entering the aquifer. Arsenic and fluoride are carcinogenic in nature and the effects range from short term to long term health degradation. There were no detectable levels of arsenic in the water column which is very recommendable. The fluoride concentrations of the water ranged 0.236-0.578 mg/l which is very low and does not pose any kind of threat to the human health. This study has been conclusive on determining the range and variation of different parameters within borough X of Kolkata municipal area.

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