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ASSESSMENT OF HEAVY METALS IN SABARMATI RIVER: A CASE STUDY BEFORE AND DURING THE LOCKDOWN

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ABSTRACT

Sabarmati is one of the largest rivers in Gujarat and passes through cities like Gandhinagar and Ahmedabad. The municipal pollutants majorly in the river comprise of untreated domestic and sewage wastes. In contrast, industrial pollutants constitute the discharge of heavy metals into the river, responsible for increasing metal load in the water. Increasing heavy metal concentration in the water can cause severe problems. In this work, Cu, Mn, Fe, Cr, Zn, Pb, and Cd heavy metals were analyzed from the five selected sites for two years, 2020 and 2021, in Two seasons pre and post-monsoon. In the year 2020, there was a lockdown situation because of Covid-19, so all industrial the activities were shut down. Therefore pollution levels were decreased, and the environment was clean at that time. Our study indicates that in the pre-monsoon season in 2020, Iron metal was highest, and in post-monsoon, Chromium was the highest. In the Post-monsoon season 2020, Iron metal was the highest, and Lead was the highest in the post-monsoon season. Because of the covid-19 lockdown, the result of post-monsoon 2020 shows the low concentration of heavy metals.

Keywords:- Sabarmati river, Heavy metal, Chromium, Lead, pre-monsoon, post-monsoon, Covid-19, Iron

1. INTRODUCTION

In the life of the people of India, Rivers play a significant role. India's rapidly developing cities like Delhi, Kanpur, Ahmedabad, and Varanasi are located on the riverbanks of the rivers like Yamuna, Ganga, and Sabarmati. These rivers receive a massive amount of toxic chemical effluent from various natural and manmade sources (Kar et al., 2008, Singh et al., 2014). Presently, in many sectors, heavy metals are widely used, e.g., in automobiles, pesticides, dental amalgams, mining industries, household appliances, photo-chemicals, paints, photographic papers, etc. (Lohani et al., 2008, Kumar N.R. et al. 2012).

Preserving and maintaining natural water resources have become an increasingly arduous task. As time passes, the demand for potable water is high because of rapid growth in population and increased industrial activities. The River Sabarmati is one of the major rivers of Gujarat, which travel across the alluvial plains of Gujarat. The origin of the river is North latitude of 24°40' in the Aravalli hills, and the East longitude of 73°20' in the Rajasthan at the elevation of 762 meters above mean sea level. From the head to the outfall into the sea, the river's total length is 371km.

The river basin covers an area of two states, Rajasthan and Gujarat. It provides a good water source for domestic, agricultural, and industrial activities because the river passes through many rural and urban areas and many industrial areas. The study's sample sites are rural areas like Gandhinagar, a low polluted zone. Then Ahmedabad, a moderated polluted zone, and some highly polluted zones like Vtava GIDC. These industrial units discharge their untreated effluent into the Sabarmati River, leading to pollution of the water body and posing a severe risk to human health, aquatic biota, and animals (Shah A.N. et al., 2008, Kumar N.R. et al., 2012).

Heavy metal accumulation in the river is flawed in mining processes, discharge, dumping of solid waste containing metal and salt, the release of industrial effluents containing metallic solutions, and some agricultural practices such as the use of total metal-based biotics. It will enter the human body mainly through food and water can cause some severe health issues, including carcinogenesis (Schwartz, 1994).

Lead is ubiquitously present, heavy metal with consequences that range from cognitive impairment in children to peripheral neuropathy in adults. Lead poisoning also causes neuromuscular and central nervous system disorders (Kaur, 2012). It enters the human body by inhaling dust from Lead paints, various foods, notably fish and plants. The heavy metal copper present at low concentration causes headache, vomiting, nausea, and diarrhea. It is an essential nutrient at low concentrations but causes serious health issues at higher concentrations. Higher copper deposition levels will lead to liver and kidney malfunctioning (USEPA, 1999). Industries like electroplating located on the river banks are the primary source of Copper in the water bodies (Boxall et al., 2000).

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Zinc is a vital element for all living beings and is involved in many physiological and industrial activities (Pillai, 1983). Sewage discharge, electroplating industries, and immersion of painted idols are the sources of Zinc in the river (Boxall et al., 2000; Dean et al., 1972). Zinc toxicity causes diarrhea, liver damage, vomiting, kidney damage. One of the most toxic heavy metals, Cadmium, is a by-product of zinc production. How Cadmium harms human health depends upon the form present and the amount taken by the human body (Bernard, 2008). Over a long time, the intake of Cd leads to bioaccumulation for the kidney and liver for years and results in kidney and liver damage. Several industrial processes like preparing Cd-Ni batteries, television phosphors, electroplating for metals like Iron, and control rods and shields in nuclear reactors used Cadmium (Dey and Paul, 2013). Due to high permeability to bio-membranes, hexavalent chromium (Cr) toxicity is more severe. Increasing the amount of Chromium has severe detrimental health effects like cardiovascular, severe respiratory, gastrointestinal, and potentially death (Bagchi et al., 2002).

2. MATERIALS AND METHODS

2.1 Study area

The present study was conducted from 2020 to 2021 during the two seasons, pre-monsoon and post-monsoon. Five sampling sites (Table-1) were selected for the study based on the random sampling method. The five sites are situated in the rural area of the Gandhinagar, urban areas of Ahmedabad, and the remaining sites are primarily found in the industrial zone of Ahmedabad. Seven heavy metals were analyzed are Iron (Fe), zinc (Zn), Copper (Cu), Cadmium (Cd), Lead (Pb), Manganese (Mn), Chromium (Cr).

The methods are outlined in Table 2. Water samples collected from the five sites on the river Sabarmati were analyzed for the concentration of heavy metals. The present study investigated the heavy metals Fe, Pb, Mn, Cr, Cu, Zn, and Cd. In this study, the sample of pre-monsoon was collected before the covid-19 lockdown. During this period, all the activities, including industrial activities, were shut down. Post-monsoon samples were collected after the lockdown.

Site no.	Site name	Coordinates
S-1	Jakshani mata mandir, Lekavada	23°16'01.3"N 72°41'30.6"E
S-2	Nabhoi, Hanuman temple	23°07'41.6"N 72°38'42.7"E
S-3	Dadhichi bridge	23°02'33.5"N 72°34'31.0"E
S-4	Narol vasana bridge	22°58'39.2"N 72°32'16.8"E
S-5	Kamod, Daskroi	22°55'50.9"N 72°32'12.6"E

Table 1:- List of sample sites

2.2 Heavy metal analysis for river water

Atomic Absorption Spectrometer analyzed the metals present in water samples. The metal quantification was based upon calibration curves of standard solutions of metals (Jain and Ali, 2001). The operational conditions were adjusted to obtain optimal analysis determination for the analysis.

Sr No.	Parameters	Unit	Acceptable as per CPCB	Permissible Limit as per CPCB	Method of Test
1	Iron (Fe)	mg/liter	Max.-0.030	No Relaxation	IS: 3025 (P-53) 2003
2	Copper (Cu)	mg/liter	Max.-0.05	Max. 1.5	IS:3025 (P-42) 1992
3	Zinc (Zn)	mg/liter	Max.-5.0	Max. 15	IS:3025 (P-49) 1994
4	Manganese (Mn)	mg/liter	Max.-0.1	Max. 0.3	IS:3025 (P-59) 2009
5	Cadmium (Cd)	mg/liter	Max.-0.003	No Relaxation	IS:3025 (P-41) 1992
6	Lead (Pb)	mg/liter	Max.-0.01	No Relaxation	IS:3025 (P-47) 1994
7	Chromium (Cr)	mg/liter	Max.-0.05	No Relaxation	IS:3025 (P-52) 2003

Table 2: - List of methods used in the study

3. RESULTS AND DISCUSSION

the observation in different sites in different seasons is depicted in figures. Since each site has different geographic locations, the anthropogenic pressure is variable. Lockdown has been a very interesting case study and unique results are obtained. Figure 1a and 1b show the comparison of the pre-monsoon of the years 2020 - 2021, and figure 2a and 2b show the post-monsoon of the years 2020- 2021. Because the samples were taken before the

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covid-19 lockdown, the pollution level is less in the post-monsoon than pre-monsoon. So, the Pre-monsoon and post-monsoon of 2020 show a minuscule amount of heavy metal concentration.

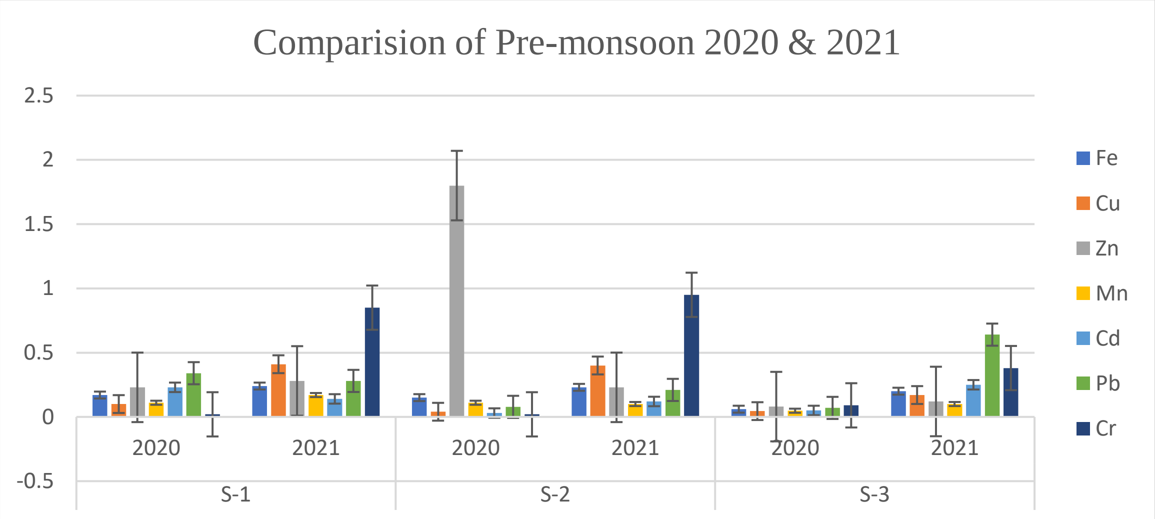

Figure 1a: Pre-monsoon water analysis data for the years 2020 & 2021 of S-1 to S-3

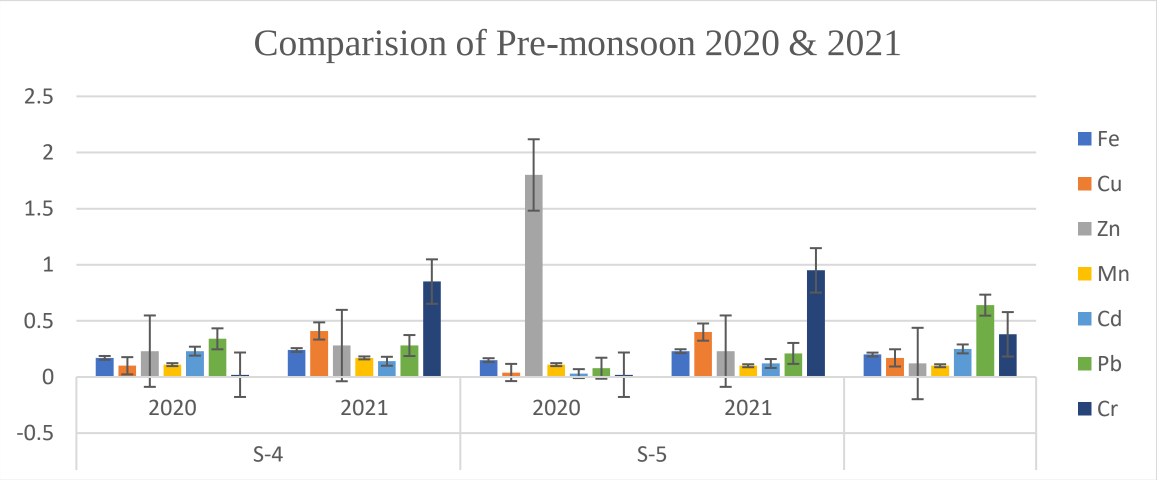

Figure 1b: Pre-monsoon water analysis data for the years 2020 & 2021 of S-1 to S-3

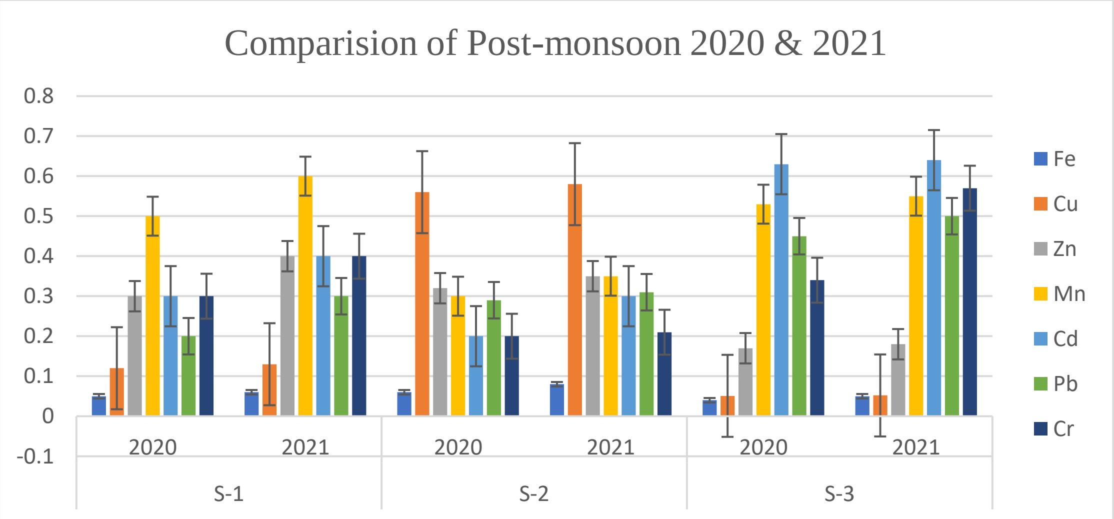

Figure 2a: Post-monsoon water analysis data for the years 2020 & 2021 of S-1 to S-3

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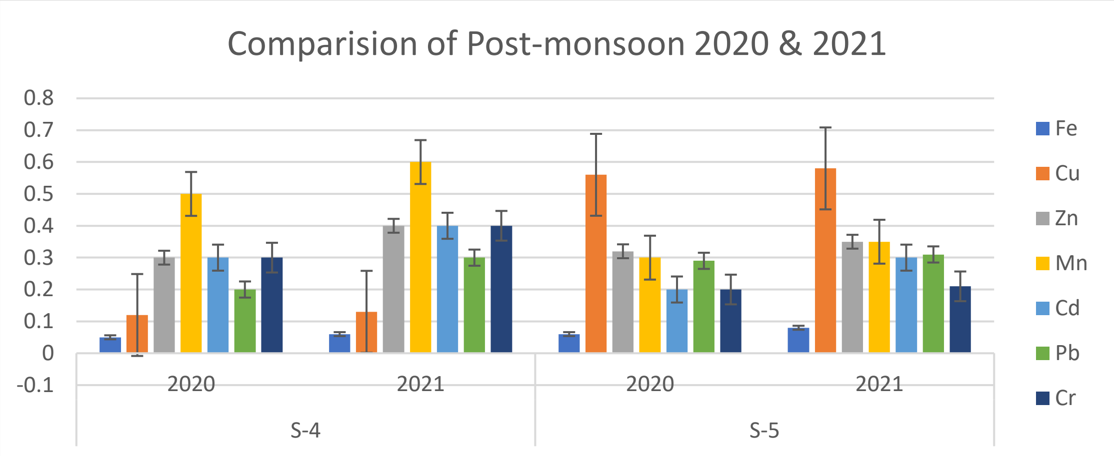

Figure 2b: Post-monsoon water analysis data for the years 2020 & 2021 of S-1 to S-3

S-1 Jakshanimata Temple, Lekavada, Gandhinagar

Results obtained during pre-monsoon sampling in 2020 show Pb > Zn ≈ Cd > Fe > Mn > Cu > Cr (Fig 1a), which shows Lead is maximum, Chromium is minimum. While in 2021 shows Cr > Cu > Zn ≈ Pb > Fe > Mn > Cd (Fig 1a) where Chromium is maximum, and Cadmium is minimum.

Results were obtained during post-monsoon sampling in 2020 Cu > Mn > Cr ≈ Cd ≈ Zn > Pb > Fe (Fig 2a), where Copper is maximum; Chromium, Cadmium, and Zinc are the same, and Iron is minimum. While in 2021 shows Cu > Mn > Cr ≈ Zn > Cd > Pb > Fe (Fig 2a), where Copper is maximum, Chromium and Zinc are the same, and Iron is minimum.

S-1 is located in the rural area of Gandhinagar, where trees surround on both sides of the riverbank; no interference from the local public; therefore, the results show low pollution. The results showed as per the CPCB guidelines, all the results of heavy metals are under acceptable limits, so the quality of water is drinkable and good for other adjoining habitat also.

S-2 Nabhoi, Hanuman Temple, Gandhinagar

Results were obtained during pre-monsoon sampling in 2020 Zn > Fe > Mn > Pb > Cu > Cd > Cr (Fig 1a), where Zinc is maximum and Zinc are the same, and Chromium is minimum. While in 2021 shows Cr > Zn ≈ Fe > Pb > Cd > Cu > Mn (Fig 1a), where Chromium is maximum, Iron and Zinc are the same, and Manganese is minimum. This is because, many agricultural farms located both the side of the riverbank, the higher concentration of Zinc in sediment may be responsible for the presence of unused remains of Zinc sulphate in fertilizers (Kumar et al., 2012, Reza & Singh, 2010).

Results were obtained during post-monsoon sampling in 2020 Cu > Zn > Pb > Mn > Cd ≈ Cr > Fe (Fig 2a), which shows Copper is maximum, Cadmium and Chromium are the same, and Iron is minimum. While in 2021 shows Cu > Zn ≈ Mn > Pb > Cd > Cr > Fe (Fig 2a), where Copper is maximum, Zinc and Manganese are the same, and Iron is minimum.

The S-2 is located in the rural area of Gandhinagar, where minimum interference of local people and no industrial activities. Trees and farms are located on both sides of the riverbank. Therefore, pollution is low and can be categorized in the drinking water category. The result shows All the results of S-2 come under the acceptable and permissible limits of the CPCB guidelines.

S-3 Dadhichi Bridge, Ahmedabad

Results were obtained during pre-monsoon sampling in 2020 Cr > Zn > Pb > Fe > Cd > Cu > Mn (Fig 1a), where Chromium is maximum, and Manganese is minimum. While in 2021 shows Pb > Cr > Cd > Cu > Zn > Fe > Mn (Fig 1a), where Lead is maximum, and Manganese is minimum.

Results were obtained during post-monsoon sampling in 2020 Cd > Mn > Pb > Cr > Zn > Cu > Fe (2a), where Cadmium is maximum, and Iron is minimum. While in 2021 shows Cd > Cr > Mn > Zn > Pb > Cu > Fe (2a), where Cadmium is maximum, and Iron is minimum.

S-3 is located in the city area of Ahmedabad at the Riverfront. Both the side of riverbank surrounded with infrastructure and there is no discharge of industrial effluent and municipal sewage water. The results of the S-3 are above the acceptable limit and under the permissible limit but can be categorized into the drinking water category.

S-4 Narol-Vasana bridge, Ahmedabad

Results were obtained during pre-monsoon sampling in 2020 Fe > Cr > Zn > Cu > Mn > Cd > Pb (1b), where Iron is maximum, and Lead is minimum. While in 2021 Fe > Cr > Cu > Pb > Mn > Zn > Cd (1b), where Iron is maximum, and Cadmium is minimum.

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Results were obtained during post-monsoon sampling in 2020 Fe > Zn > Pb > Cu > Mn > Cd > Cr (2b), where Iron is maximum, and Chromium is minimum. While in 2021 Fe > Zn > Pb > Cu > Mn > Cd > Cr (2b), where Iron is maximum, and Chromium is minimum.

S-4 is located in a highly polluted area where industrial activities are highly activated. S0, the results of S-4 are above acceptable and permissible limits except for Zinc. Industries like Iron, steel, dying, etc., are located near the site. They release untreated effluent and sewage water directly into the river. GIDC and industries surrounding this site have encouraged a new kind of medium and small industries like engineering and chemical units generating significant water pollution.

S-5 Kamod, Daskroi

Results were obtained during pre-monsoon sampling in 2020 Fe > Cr > Zn > Cu > Mn > Pb > Cd (1b), where Iron is maximum, and Cadmium is minimum. While in 2020 Fe > Cr > Zn > Cu > Mn > Pb > Cd (1b), where Iron is maximum, and Cadmium is minimum.

Results were obtained during post-monsoon sampling in 2020 Fe > Pb > Zn > Cu > Mn > Cd > Cr (2b), where Iron is maximum, and Cadmium is minimum. While in 2021 Fe > Pb > Zn > Cu > Mn > Cd > Cr (2b), where Iron is maximum, and Cadmium is minimum.

S-5 is located in the rural area, but the untreated industrial discharged into the river have dragged to the S-5. The pollution is because of that industrial pollution at this site. Farmers of the village use this untreated water for irrigation, and they have told that because of the high heavy metals present in the water, the crop yield is good after using this water.

The levels of heavy metals during pre-monsoon and post-monsoon in any water sample varies. Pre-monsoon data usually depicts a higher metal load while in post-monsoon samples the river water being flooded with additional rainwater usually depicts lesser metal load. Anthropogenic pressure contributes heavily to generating pollutants and when disposal options are unavailable, natural water bodies are generally used to get rid of the pollutants. Awareness and feeling the sense of responsibility towards the environment by the industrialists can be a big help in preventing such pollution.

A severe human health issue based on ubiquitous environmental presence has happened by the exposure of toxic heavy metals (Singh s. et al.,2014, Ray et al., 2014). Heavy metals like Fe, Cu, Zn, Mn, Cd is present at a high level and can enter our food chain through the food that prepare with the vegetables grown on the banks of the river and accumulates in the different body parts. It can cause impaired metabolism and reduce the growth of our body eventually. According to Singh.S. et al., 2014; Cunningham, 1997 and Kasprzak, 1995, the cell nucleus binding with the metal ion causes premutagenic damage by the production of reactive oxygen species, which leads to metal-medicated carcinogenicity and acute toxicity.

4. CONCLUSION

The seasonal study of heavy metals concludes that water samples collected from five different sites of the Sabarmati River indicate the high concentration of the heavy metal is shown in the Fig 1a 1b;2a 2b and first three sites are between low to moderated pollution zones. The first two sites are situated in the rural area of Gandhinagar. The third site is located in urban areas. The last two sites are located in the industrial zones of Ahmedabad. The post-monsoon season of both years shows the highest concentration of heavy metals, and the low concentration of heavy metals shows in the pre-monsoon season. Because due to the covid-19 pandemic, all the industrial activities were closed, so the pollution level decreased. Reducing industrial input into the river is necessary because the local food web complexes might be at the highest risk of induced heavy metal concentration. There is a need to decrease the industrial input into the river.

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