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Dynamic nature of heavy metal toxicity in water and sediments of Ghaghara River at Azamgarh (U.P.) with climatic change

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Abstract
Heavy metal toxicity is major concern in term of water pollution. Heavy metals, some of them are potentially toxic and are transferred to the surrounding environment through different pathways. In this study, we carried out examination of concentration of Lead, Chromium, Nickel in water and sediment from River Ghaghara in Azamgarh, Uttar Pradesh, India by using Atomic Absorption Spectrophotometer. Samples of water and sediment were collected from the five different sampling sites. Samples collected in duration of ninety three days from January to April with the gap of 10-15 days during climatic changes are most. On comparison of these heavy metals concentration, it was found that concentration of Pb, Cr, and Ni were higher than the permissible limits of WHO and it increases with rising temperature and reducing humidity. The samples collected from Site 5 had higher concentration among all sites of collection.

Keywords: Water pollution, toxicity, human health, water-borne disease

1. Introduction

Water is a major source of life. Contamination of water is the major threat in today's world. Water is an important part of human and animal life and its depends upon life cycle and presence of whole bio-diversity. People cannot make or produce either of these basic fundamentals of life in a form in which persons are wanted. As such people have no right to abolish, waste with any natural resources. Wherever and in whatever those form may be establish, it is our basic duty to preserve such natural resources. Water quality has developed a severe issue due to growing industrial development Toxic waste, urbanization. The constituent existing in the water organizations depend on the nature where the water body is located and the release value from several sources in that water body (McDonald, AT and Kay, 1988 and Rai, 2019) [1-2].

Heavy metals can also be loosely defined as a subset of elements that exhibit the properties of metals. It contains transition metals, some metalloids, lanthanides and actinides. Using density as a determining factor, also different heavy metals such as those having an exact density greater than 5 g/cm^3(Suciu *et al.* 2008) [3]. Heavy metals covering farming runoff enter in aquatic atmosphere, it may toxic to aquatic plants and animals. If compostable waste such as sewage sludge, municipal solid waste and pig manure contain heavy metals, it may modification the composting procedure by preventing bacterial growth. In the vermicomposting procedure heavy metals affects earth worm life cycle (Singh and Kalamdhad, 2011) [4]. Heavy metals represent one of the most dangerous groups due to their persistent nature, toxicity, affinity to accumulate in organisms and experience the increase of the food chain, in addition to being non-degradable. Water bodies can develop polluted by the growth of heavy metals and metalloids from discharges from rapidly developing industrial areas, disposal of high-metal wastes, leaded gasoline and paints, application of fertilizers, animal manures, sewage sludge, pesticides, sewage irrigation, and electronic waste.There are several studies which infer that there is change in water environment in terms of concentration of heavy metals during climatic change (Rajan *et al.* 2012, Arnell *et al.* 2015 and Rai, 2022) [5-6, 15]. This had been noted that dissolved heavy metals concentration are more in rise in environmental temperature as compare to cold weather. Heavy metal poisonousness has established to be a major risk and there is several health threats related with human and animal. The toxic effects of these metals, even though they do not have any organic role, persist current in approximately or the other form damaging for the people body and its suitable working. Consequently, the aim of the present study was to measure the concentration of heavy metals from the Ghaghara River during winters and summers to appreciate the change in dissolved heavy metal concentrations.

2. Study site

The district of Azamgarh comprises a somewhat irregularly shaped tract of country lying south of the Ghaghra river, between the parallels of 25°38" and 26°52" north latitude and the meridians of 82°40" and 83°52" east longitude. The administrative hq. of Azamgarh is on Lucknow-Baliya state highway, 269 km. from capital Lucknow.

Ghaghra river has its origin in the mountains of Kumaon and Nepal and is formed by the combined waters of the Cuauka, Kauriala, Rapti and many smaller streams. It swells during the rains to an immense size, when its current becomes very rapid, and damage from floods in often severe. It will at times from one or more subsidiary channels, into anyone of which it may suddenly turn its whole force, tearing through the intermediate land. At such time it deposits nothing but sand, but at other times it will confine itself to a single channel and lays down stretches of fertilizing silt. The Ghghra makes the northern boundary of the district and separates it from Gorakhpur.

3. Materials and Methods

3.1 Samples collection: The water samples were collected from the five different Sites of Ghaghara River at Azamgarh, Uttar Pradesh, India. Site 1:- Baluwa Bhawanibux, Site 2:-Zrazi Tighra, Site 3:-Arazi Loharaiya, Site 4:- Arazi Terhmuhi; Site 5:-Arazi Bakainiya (Figure 1).

All sampling sites were used for Farming and drinking and considered to be more polluted due to human activities. Water samples were collected for analysis from each Site. All samples were collected in 1.5liter of sterile polyethylene bottles, which were pre-washed with 10% nitric acid and de-ionized water. Before sampling, the bottles were rinsed at least three times with water from the sampling site. The bottles were immersed to about 20cm below the water surface to prevent contamination of heavy metals from air. Sediment Samples were also collected for analysis from each site. All samples were collected in sterile polyethylene bag.

All water samples were immediately brought to the laboratory where they filtered through Whatman No.41 (0.45µm pore size) filter paper. The samples were acidified with 2ml concentrated Nitric acid to prevent precipitation of metals, reduce adsorption of the analyses onto the walls of containers and to avoid microbial activity, then water samples were stored at 4 °C until the analyses.

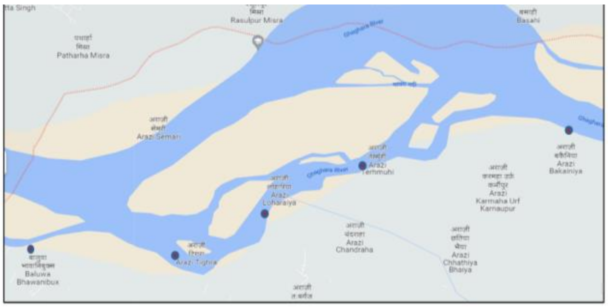

Fig 1: Five sites location in google map along the Ghaghara River

3.2 Digestion of sediment samples

For extraction of heavy metal from sediments, the standard method described by American Public Health Association, toxicological manual was followed (Tiwari, 1976) [17]. Three representative subsamples each of about 1g of dried soil was digested with 15ml of a 5:1:1mixture of nitric acid, sulphuric acid and perchloric acid in water bath maintained at 80 °C until a transparent solution was obtained. After cooling, the solutions were filtered through Whatman filter paper and diluted to 100ml with de-ionized water (Singh *et al.* 2010) [8].

3.3 Instrumentation

The concentrations of heavy metals were determined in all samples by Atomic Absorption Spectroscopy (Element AS AAS4141). It is a standard laboratory analytical tool for metal analysis and is based on the absorption of electromagnetic radiation by atoms.

4. Results and Discussions

The concentration of lead, nickel and chromium concentration in water and sediment collected in every 10-15days during four months from January to April 2022 from Ghaghara river were measured and compared with the permissible limits as set by the World Health Organization (WHO).

4.1 Concentration of heavy metals in water samples

4.1.1 Lead (Pb): In the month of January, the concentration of lead (Pb) in water was 0.350 ppm, followed by a sudden increase in February (0.988 ppm), which further increased in March (1.092 ppm) and continued to increase in the month of April, where the concentration of lead in water was 1.996 ppm. The maximum permissible limit of lead according to the WHO guideline is 0.01 ppm. Compared to this limit, the concentration of lead is very high than the permissible limit, it can cause severe lead toxicity in humans and animals. The level of lead in the month of April is almost 200 times higher than the limit set by the WHO (Figure 1). As the climate temperature increases and humidity decreases, there is an increase in dissolved heavy metals. There is a significant difference between the WHO limit and the levels measured during these months. When comparing levels between these months, we find significant differences in Pb concentrations in different months (Table 1).

4.1.2 Nickel (Ni): In month of January the concentration of nickel (Ni) in water samples was 0.537 followed by slight decrease in February concentration was 0.466, whereas there was increase in the March (0.784) and further it increases in month of April, the concentration of nickel in water was 1.143. According to the WHO guidelines, maximum permissible limit of nickel is 0.02 ppm. We found that concentration of nickel is very high as compared to the permissible limit, and almost 60times higher than WHO limit in month of April. There were significant differences between the concentration of WHO limit and Ni levels measured during these months. On comparison of the concentration of Ni among the different months, we found significant differences in concentration of Ni in different months (Table 1).

4.2 Chromium (Cr): In month of January the concentration of chromium (Cr) in water is 1.194 ppm followed by February concentration of chromium is 0.935 ppm and in the month of March, the concentration is 1.10 ppm and in month of April is 1.82 ppm. The WHO guideline for maximum permissible limit of chromium level is 0.001 ppm. The concentration of chromium in Ghaghara river water sample is higher than the permissible limit, and it is almost 1800times higher than the permissible limit in the month of April. There is significant difference between the WHO limit and Ni levels measured during these months. On comparison of the levels among these months, we find significant differences in concentration of Pb in different months (Table 1).

4.3 Concentration of heavy metals in sediment samples

4.3.1 Lead (Pb): The concentration measured from the sediments in the month of January was 19.013 ppm followed by steep increases by February, the concentration of Lead was 33.309 ppm. In the month of March, the concentration of dissolved Pb increases to 42.048 ppm and small increase was further noted in month of April (48.989 ppm). The concentration of Lead in Ghaghara river sediment sample is higher than the permissible limit (10 ppm), and it is almost 4times higher than the permissible limit in the month of March and April. There is significant difference between the WHO limit and Ni levels measured during these months. On comparison of the levels among these months, we also find significant differences in concentration of Pb in different months (Table 1).

4.3.2 Nickel (Ni): The concentration of nickel in sediments was found to be 32.002 ppm in samples collected in January. There is increase in concentration by February and measured 38.362 ppm where steep increase was noticed in the month of March and April, the concentration was 44.816 ppm and 60.035 ppm respectively. The concentration of nickel in Ghaghara river sediment sample is higher than the permissible limit (20 ppm), and it is almost 3times higher than the permissible limit in the month of April. There is significant difference between the WHO limit and Ni levels measured during these months. On comparison of the levels among these months, we find significant differences in concentration of Ni in different months (Table 1).

4.3.3 Chromium (Cr): In month of January the concentration of Chromium in sediment was 38.764 ppm, which increases in month of February (47.596 ppm) and in the month of March, the concentration further increases abruptly to 69.427 ppm and continued to month of April to 81.516 ppm. The concentration of Chromium in Ghaghara river sediment sample is higher than the permissible limit (25 ppm), and it is almost 3times higher than the permissible limit in the month of April. There is significant difference between the WHO limit and Ni levels measured during these months. On comparison of the levels among these months, we find significant differences in concentration of Pb in different months (Table 1)

4.3.4 Climatic changes and level of heavy metals in water and sediments

January is the coldest month of the four months with an average temperature of 20 °C and there is an increase in temperature with the months before the year. In comparison, we found that there is a consistent increase in heavy metal levels with increasing temperature. From January to April, each month there is a change of 3 °C on average and a change in the concentration of heavy metals in sediments and in water. In the water samples, we find a sudden drop in the concentration of heavy metals in the month of January, followed by a continuous increase in the concentration of heavy metals with an increase in temperature. In sediments, we found that there is a constant increase in the concentration of heavy metals. We observed a similar type of behavior with the level of humidity in the environment, because as the temperature increases, the humidity decreases, and the concentration of heavy metals increases. This dynamic nature of heavy metal concentration levels in the Ghaghara River with respect to climate change should be accounted for and considered for further stratification of preventive measures.

In term of the different sites of collection, we found that Site 5 had more concentration than any other sites of collection for most of the samples for both water and sediments, whereas others sites are most nearby the average (Table 1). Although Site 3 had low concentration of Cr compare to five sites of sample collection.

Table 1: Concentration of Heavy metals (Pb, Ni, Cr) in water and sediments collected from different sites of River Ghaghara, Uttar Pradesh, India

Collection sites	Conc of Pb (ppm)		Conc of Ni (ppm)		Conc. of Cr (ppm)	
	Water	Sediment	Water	Sediment	Water	Sediment
S1	0.799	36.928	0.628	42.626	1.068	61.198
S2	0.826	39.099	0.562	41.872	1.232	59.399
S3	1.158	33.374	0.771	46.321	1.024	54.447
S4	1.314	31.668	0.854	50.066	1.376	55.845
S5	1.406	39.14	0.856	38.755	1.614	67.336

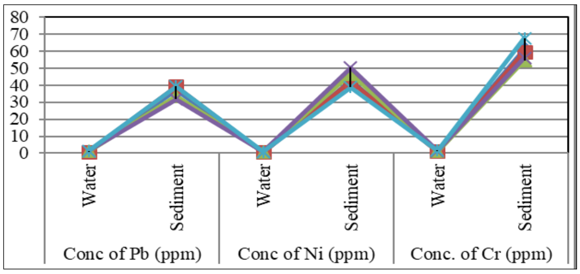

Fig 2: Graph analysis of Heavy metals (Pb, Ni, Cr) in water and sediments collected from different sites of River Ghaghara, Uttar Pradesh, India

Heavy metals are found in various water bodies and are harmful to both aquatic life and human life. In the previous literature, there are many studies related to heavy metal toxicity that report heavy metal levels in water bodies from time to time. WHO has strictly suggested the permissible limit, but most water bodies are contaminated by polluted water discharged from industries and nearby factories. Based on research on drinking water samples, they contain concentrations of heavy metals higher than permissible and desirable levels (WHO). Most of the water samples were highly contaminated, which cannot be used for drinking purposes. Toxicologists have been constantly investigating the concentration of heavy metals in various water bodies. The increase in natural pollution makes water and fish unfit for consumption, which can cause serious health problems.

Ghaghara River is the main water bodies in Azamgarh district from which water is supplied to most of the households. The heavy metal toxicity in river bodies is serious problem and should be addressed by environmental protection leaders. In this study, we found the most of water and sediment samples collected from 5 sites had higher concentration as per the WHO limits, which means there is continuous exposure of this river with heavy metal contamination through various sources. In Ghaghara River, previous study reported Pb concentration (1 ppm), and showed improved total dissolved solids (TDS) and biological oxygen demand (BOD) may recommend increased organic matter (OM) within the river from industrial release, contaminated water and wastes and ability of self-purification. In a study, it was found that the recorded concentration of Pb was 0.06 ppm (Usman *et al.* 2017) [9] while in present study, the Pb concentration was very high (1.099 ppm), for Chromium concentration in water is 0.14 ppm (Obaroh *et al.* 2015) [10] while in our research we found Chromium concentration in water as 1.261 and for Nickel concentration in water is 1.02 ppm (Obaroh *et al.* 2015) [10] while in our research we found Nickel concertation in water 0.733 ppm. Lead concertation in sediment is 25.1 ppm (Zhenyong**,** 1992) [11] while in our research we found Pb concentration in sediment 35.839 ppm, for Cr concentration in sediment is 58.40 ppm (Ebenstein, 2012) [12] while in our research we found Chromium concertation in sediment 59.325 ppm and for Nickel concertation in sediment is 67.08 ppm (Ebenstein, 2012) [12] while in our research we found Nickel concertation in sediment 43.803 ppm. One of the largest rivers in India, Ganga, also reported to be higher levels of heavy metals concentrations (Paul, 2017) [13]. These heavy metals are toxic and enters in environment may lead to bioaccumulation and biomagnification. This increase in heavy metals concentration is related to industrial waste discharges which are released to water bodies' untreated leading to increase in these toxic heavy metals concentrations. In present study, this is noted by the data evaluated on the basis of different sites, site 5 had higher concentration among the five sites, as we located most of industrial discharges are nearby site 5.

In one of the study conducted in Malaysia in water tributaries found that there is increase in dissolved heavy metals pre-monsoon as compared to post monsoon (Rajan *et al.* 2012) [5]. Another study also suggested increase of concentration of heavy metals in summers and less humid environment (Whitehead *et al.* 2009) [14]. The possible reason for the increase in concentration is reduced water levels during summer or increase in temperature.

5. Conclusion

Concentrations of heavy metals in most river bodies have already exceeded or are on the border of the permissible limit declared by the World Health Organization. Although some previous data indicate that somewhere the concentrations of elements are still below the permissible limit. Human health is directly affected by the consumption of polluted water, sediments, fish, fruits, vegetables, plants, etc. Studies show that industrial wastes, electronic waste, wastewater, natural resources, anthropogenic sources and agricultural activities that have contaminated hazardous and toxic substances in the water of Ghaghara river thus led to pollution of drinking water in nearby areas. Diseases like neurotoxicity, carcinogenicity basically related to heavy metal contamination in water like Pb, Cr and Ni are also prevalent in these areas. The practice of trace element detection should be continued to reduce the possible consumption of contaminated food. People should be aware of the dangerous effects of consuming contaminated water and food.

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