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An Assessment of Chromium Pollution in Sukinda Mines, Odisha

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Abstract

Mining the necessity of today's world, which makes the mining of chromium important and valuable all over the world. Chromium is major mineral deposited in Sukinda valley, Jajpur, Odisha which contributes to 2% of chromium deposition in the world. The extraction of hexagonal chromite is affecting the environment in downward way.

AIM: The present study aims to focus on the amount of chromium pollution in Sukinda valley.

Methodology: includes by collecting samples from different sites in Sukinda valley and analysing various physiochemical parameters in the samples.

Result: A correlation plot was generated to relation between physiochemical parameters and contributes to chromium pollution simultaneously. As a result, the chromium pollution is independent, as correlation has

not been seen with chromium. However, other factors were seen to affect water quality and leading to pollution.

Interpretation: practical validity of the study

Introduction

Mining is an ancient practice carried out in various parts of the world for the growth of human civilization (Nayak ***et al.*** 2020). With the ever-increasing demands for resources, here minerals have advances ore-extraction techniques which had escalated with time. Mining is known to be "Necessary evil" as it provides employment, material, precious gems, however, affects the environment in deteriorating manner (Jaishankar ***et al.*** 2014; Nayak ***et al.*** 2020). With the advancement and to maintain economic stability, the country has been highly dependent on mineral rich resources, the mining sector has been playing necessary role in maintain economy (Das ***et al.*** 2021). About 3000 mines in India, employing more than 5 Lakh employees on daily basis are much affected by the harmful heavy chemicals released while mining affecting both worker's health and environment (Das ***et al.*** 2021).

Chromium is commonly occurring element on earth's crust (Pattanaik ***et al.*** 2012) and majorly grounded in South Africa, India, Kazakhstan, Brazil, and Turkey. India contributes to 2% of total chromium resource in the world (Das ***et al.*** 2021). Chromium is one of the chief minerals deposited in Sukinda valley, Jajpur, Odisha (Das ***et al.*** 2013), historically Chromite deposits were discovered in Sukinda valley in 1950s (Pattanaik ***et al.*** 2012) accounting 97% chromite deposits in India (Das ***et al.*** 2013) and remaining in states of Jharkhand, Karnataka, Goa, Maharashtra, Tamil Nadu, and Andhra Pradesh (Das ***et al.*** 2021), which is strategic mineral due to its limited reserve potential (Pattanaik ***et al.*** 2012). Chromium is an industrial metal used in the manufacturing of stainless steel and metallurgy, chemical processing, and several other commercial products (Nayak ***et al.*** 2020). Chromites in the study area are predominantly stratified in nature (Chakraborty ***et al.*** 1984; Pattanaik ***et al.*** 2012), the width of chromite bands differs from 3-50 meters and separated by each other by limonite and pyroxenite; also, in its hexagonal form which makes the mineral toxic (Das ***et al.*** 2021). There has been an increased demand for chromites in recent years, where in the opencast mining chromite ore and rock wastes are discarded on open grounds leading to environmental and topography damage (Dutta, 2013) causing leaching of chromium affecting water bodies (Dhakate ***et al.*** 2008). Thus, hexavalent chromium affects and influence accumulation and toxic effect on aquatic ecosystem (Pande and Sharma, 1999; Abdu ***et al.*** 2017; Nayak ***et al.*** 2020) and human health (Peng and Guo, 2020).

As it is known, lakes and their sediments are often used as indicators of environmental pollution especially for the deposition of heavy metals reflecting the effect of human activity on the aquifer (Noli and Tsamos, 2018).

Pollution has become a major issue around the globe. Aquatic ecosystem is more susceptible to heavy metal contamination by extensive industrialization and rapid urbanization (Rashmi ***et al.*** 2019). The aquatic ecosystem receives anthropogenic wastes and become ultimate depository of heavy metals. Heavy metals are identified as metallic element that have a relatively higher density in contrast to water. Once, the heavy metals enter to living organisms through food chain, it becomes irreversible (Rashmi ***et al.*** 2019). Bio-accumulation of these pollutants in aquatic organisms such as fish from different water bodies depends on the intensity of pollution (Rashmi ***et al.*** 2019). Fish physiology, metabolism, genomics, and behavior may reflect the purity of aquatic environment and its resistance to contamination by heavy metals and nanoparticles (Rashmi ***et al.*** 2019). The productivity of fish could well be enhanced by sustainable use of fish catch and the regular monitoring of the water quality (Das ***et al.*** 2021).

Hexavalent chromium is considered as highly contaminant having no known beneficial effects. Hexavalent chromium content of bottom sediment of Damsal nala in the upstream region were found below the detection limit as in BSC1 as well as in BSC2 (Dutta, 2013).

According to the review by Rashmi ***et al.*** (2019), the Carp family with exposure to chromium faces decline in red blood cell count and total leucocyte count and damages genetically. Additionally, snakehead fish family, exposure to chromium causes irregular swimming, damage of gill cells, renal destruction and heptocytic abnormalities. The Minnow family faces reduction in fertility and larvae survivability, whereas in rayfinned fishes, causes problem in liver and kidney. The cypprinidae, on exposure to chromium faces DNA damage. The present study is aimed at evaluating effect of chromium on species in Sukinda valley, Odisha hypothezing the fact of deterioration of species diversity over the period.

Study Area

Sukinda valley (21° 0' 00”– 21° 04' 07” N; 83° 43' 16”–85° 52' 30” E) or mining valley of Odisha spread in over 200 km^2, is flanked by Tomka-Daitari hills in the north, Mahagiri ranges in the east, Damsal nala to the south-west which drains the entire valley and is perennial in nature.

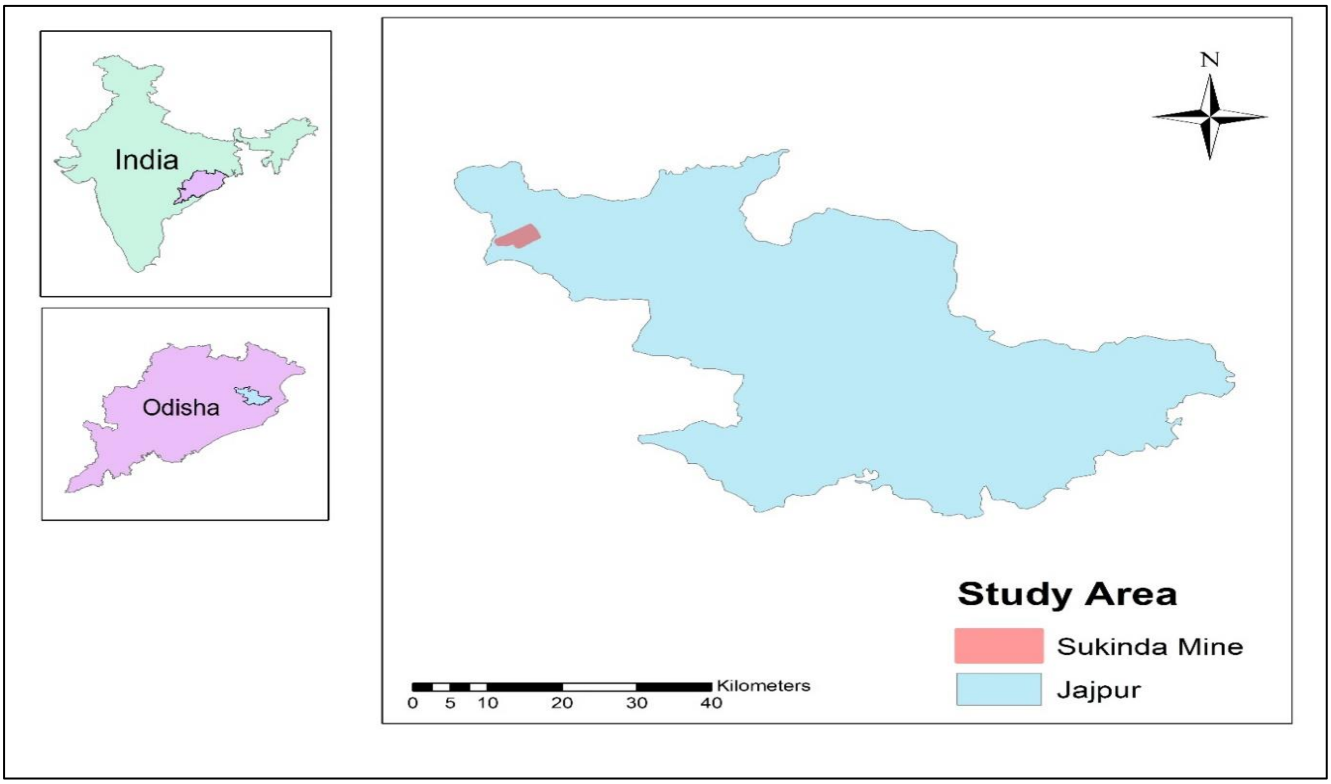

Figure 1: Map of Study area.

Table: Summary of Affected species due to Chromite Mining in Sukinda Valley

	Exposure route	Affected species	Affect observed
Chromite Mining	Air	humans	Asthma, irritation of nose, throat and lungs; ulceration and perforationin septum and lung cancer
	water	Fishes, Birds, plants	Increased hatching, increased germination phase, stunted growth
	Soil	Worms, Micro-organisms	Lower pH level of soil, reduced ; topographic disorder, disturbance in water table; crop yeilds

Methodology

Water (mine drainage water, ground water and surface water i.e., water of Damsal nala) and bottom sediment of Damsal nala were analysed to determine the impact of chromite mining in Sukinda valley region of Odisha, India. Water and sediment samples were collected at positions around the lakes. The sampling locations are shown in Fig. at each location, the samples were taken inside the lakes 1 to 3 m from the coastline. The sampling was performed from year 2019 to 2021. In order to estimate the seasonal variation of the estimated parameters, three sampling periods were selected, Pre-Monsoon (March-May); Monsoon (June-September) and post monsoon (October-February).

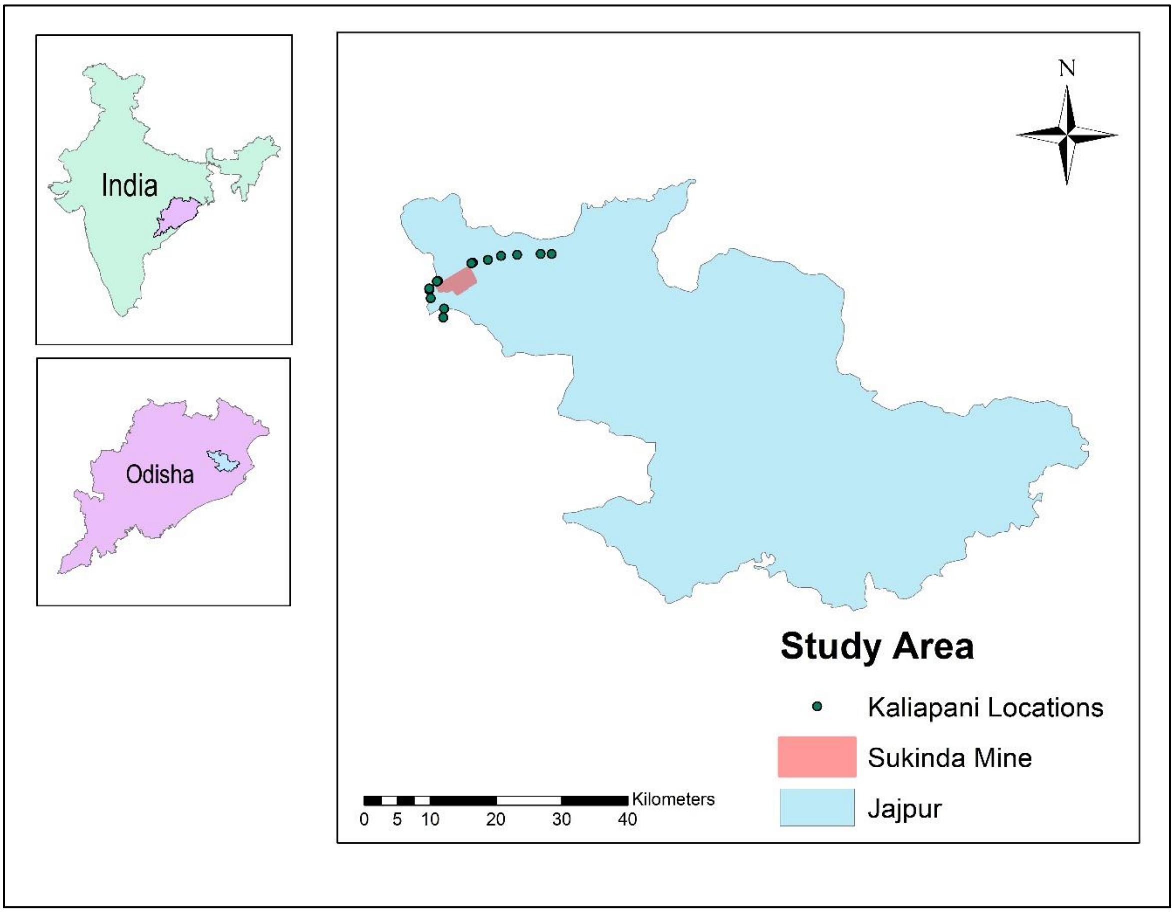

Figure 2: Map of sampling area Sukinda Mines

Result and Discussion

The pH level over the study period fluctuates between 7 to 9 (Fig 3) nearly which makes quality of water neutral to slightly basic in nature.The maximum pH value is () in the year and month followed by and the minimum

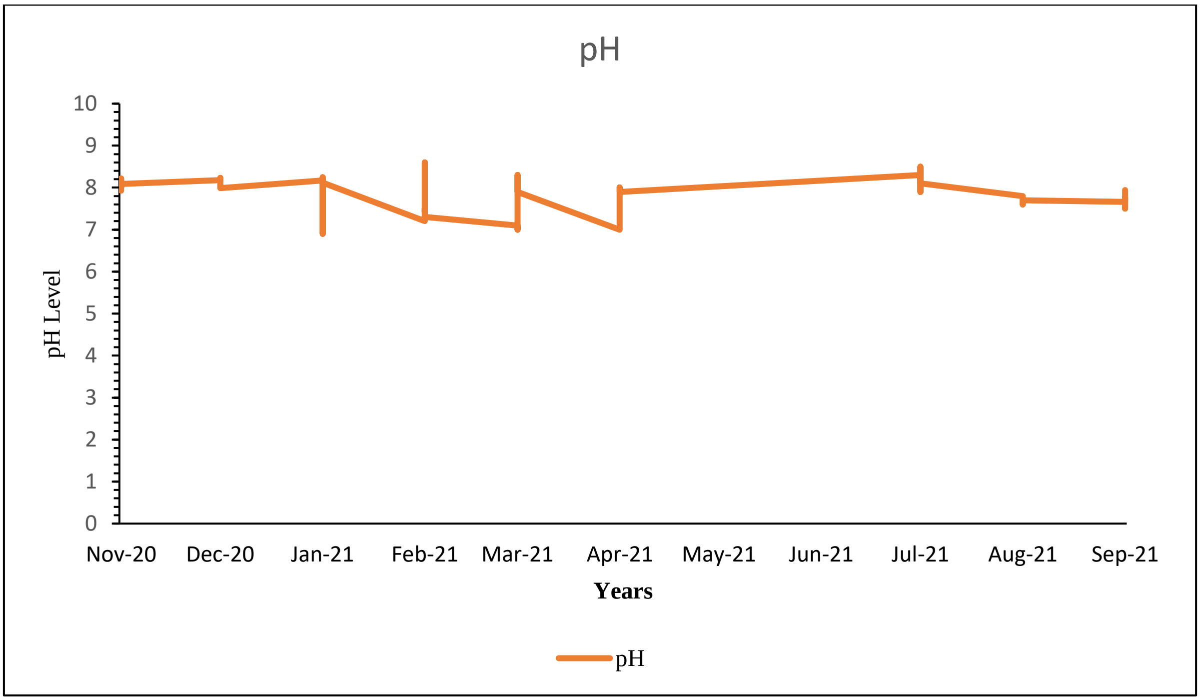

Fig 3: pH level during the study periods

Season		p^H	EC (ms/m)	TDS(gm/lt)	Cr (me/lt)	Ca (me/lt)	Mg (me/lt)	Na (mg/lt)	K (mg/lt)	Fe (mg/lt)	So4 (mg/lt)
Pre-monsoon	Mean	7.646667	0.166667	0.426667	0.145753	3.984667	2.771733	3.912667	0.422133	0.2002	15.30257
	SD (SE)	0.48677 (0.12568)	0.072375 (0.018687)	0.893202 (0.230624)	0.090767 (0.023436)	1.467967 (0.379027)	3.829749 (0.988837)	1.863382 (0.481123)	0.573082 (0.147969)	0.086031 (0.022213)	24.38676 (6.296635)

Monsoon	Mean	7.872	0.133333	0.4	0.389373	2.236	2.225067	4.444933	0.712667	0.650133	20.21
	SD (SE)	0.284158 (0.073369)	0.09759 (0.025198)	0.427618 (0.11041)	0.493272 (0.127362)	1.196625 (0.308967)	1.768192 (0.45654)	1.753581 (0.45277)	0.22029 (0.056879)	0.55297 (0.142778)	20.1407 (5.200313)
Post-monsoon	Mean	8.037333	0.173333	0.386667	0.1418	2.17	2.343333	3.385333	0.373933	0.189733	16.88633
	SD (SE)	0.330616 (0.085365)	0.088372 (0.022817)	0.266905 (0.068914)	0.097407 (0.02515)	0.712591 (0.18399)	0.994066 (0.256667)	0.885743 (0.228698)	0.376883 (0.097311)	0.143663 (0.037094)	25.597 (6.609117)

During pre-monsoon, the components of water show variation (Fig 4). The pH level in Gurujanga , Damsal and Infront of ostopal mines seems neutral i.e., 7 and quantity of calcium and SO4 measured quite close. The extreme hike and peaks of pH (about 9), calcium (40%), SO4 (80%) are seen from areas Tata and Kamarda.

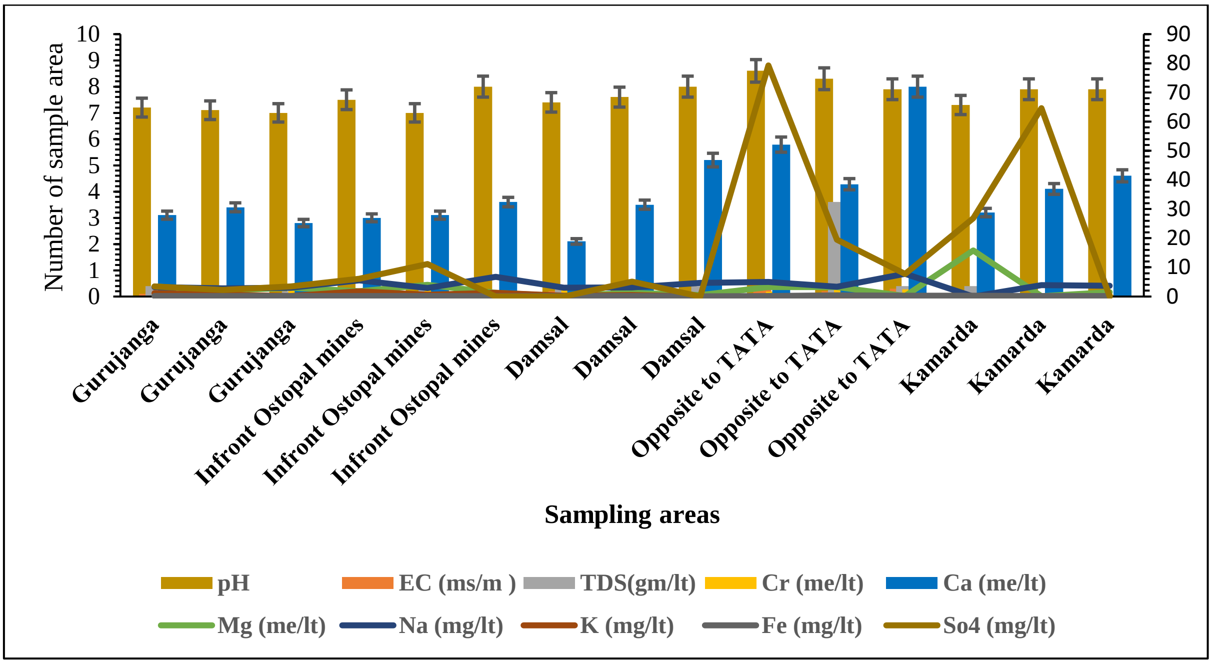

Fig 4: pH and chromium level Nov-20 to Jan-21during Pre-monsoon

Whereas during monsoon, the pH level increases reaching 8 to 9 from all study sites. Calcium spikes to 40% from Kamarda and Gurujanga. The highest spike is seen in SO4 about 70% from opposite TATA and below 10% from Ostopal and Damsal region (Fig 5).

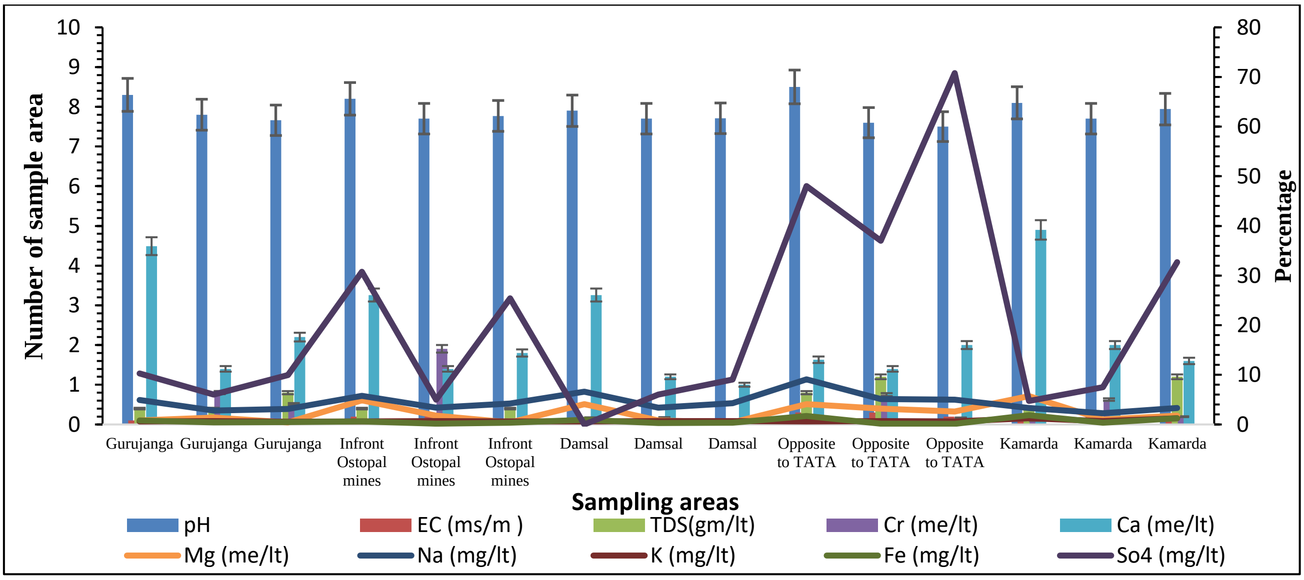

Fig 5: Monsoon pH and chromium level Nov-20 to Jan-21

However, the recording from post-monsoon (Fig 6), the pH remains same, but the quantity of SO4 reached 90% from the pposite TATA region.

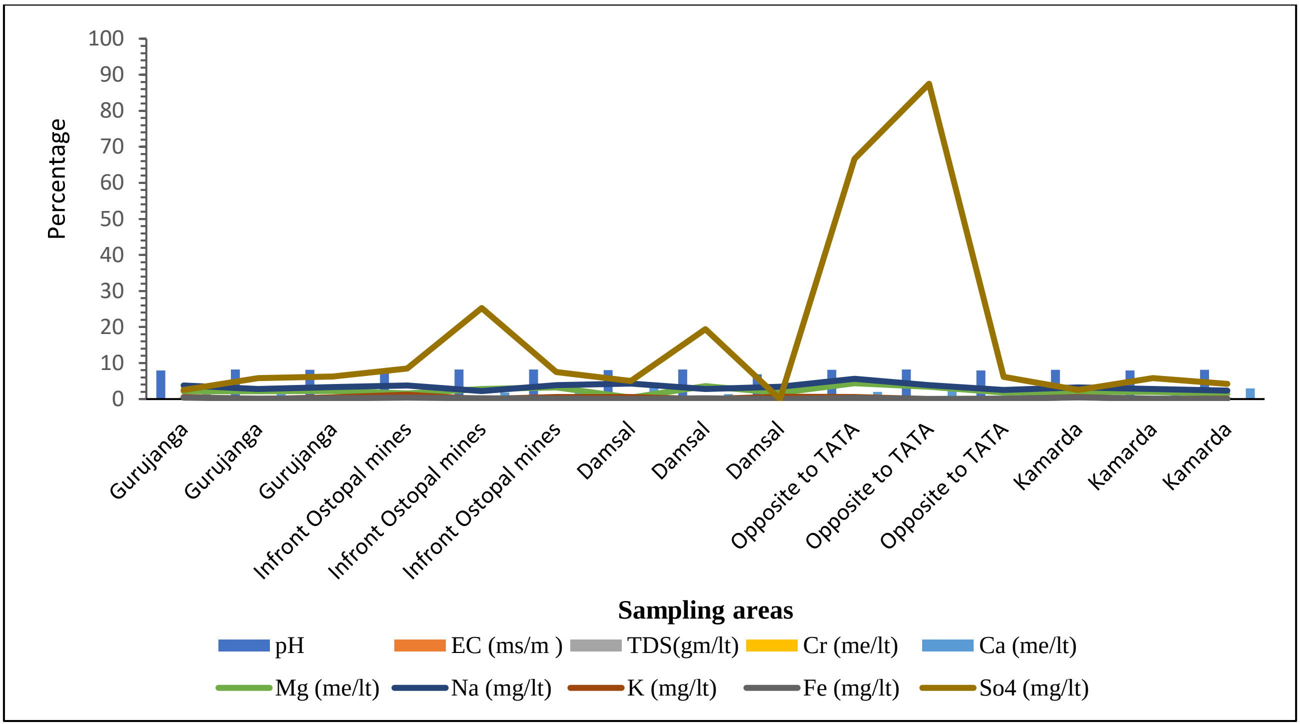

Fig 6: post-monsoon pH and chromium level Nov-20 to Jan-21

To highlight chromium pollution (Fig 7), the presence of chromium was 100% from november 2020 to September 2021 in opposite TATA, covering pre-monsson, monsoon and post monsoon followed by Kamarda about 80%, then Ostopal mines about 60%, then Gurujanga 40% and lowest in order Damsal about 20 %.

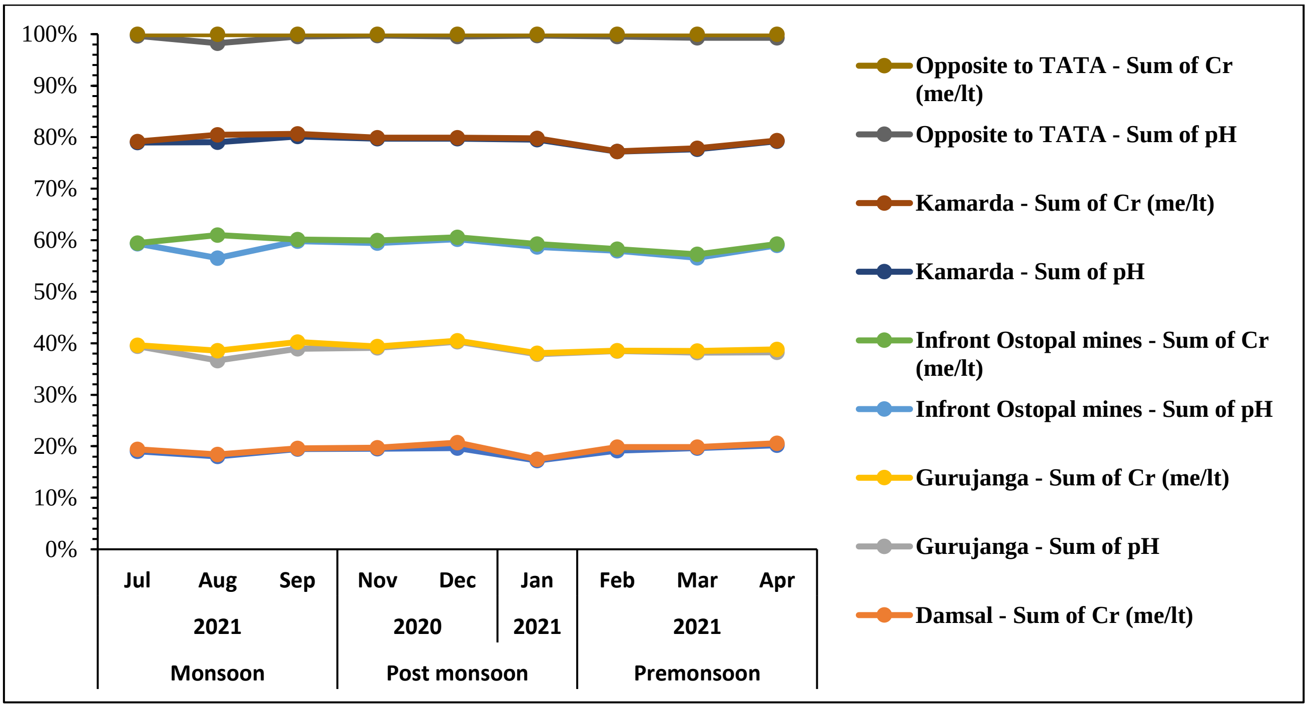

Fig 7: Level of chromium

In study area, to show physiochemical components fluctuates with increase or decrease of chromium in water samples. The following correlation plot (Fig 8) depicts chromium is affecting the level of calcium and highly correlated as p- value < 0.05 followed by related to Iron component from water samples.

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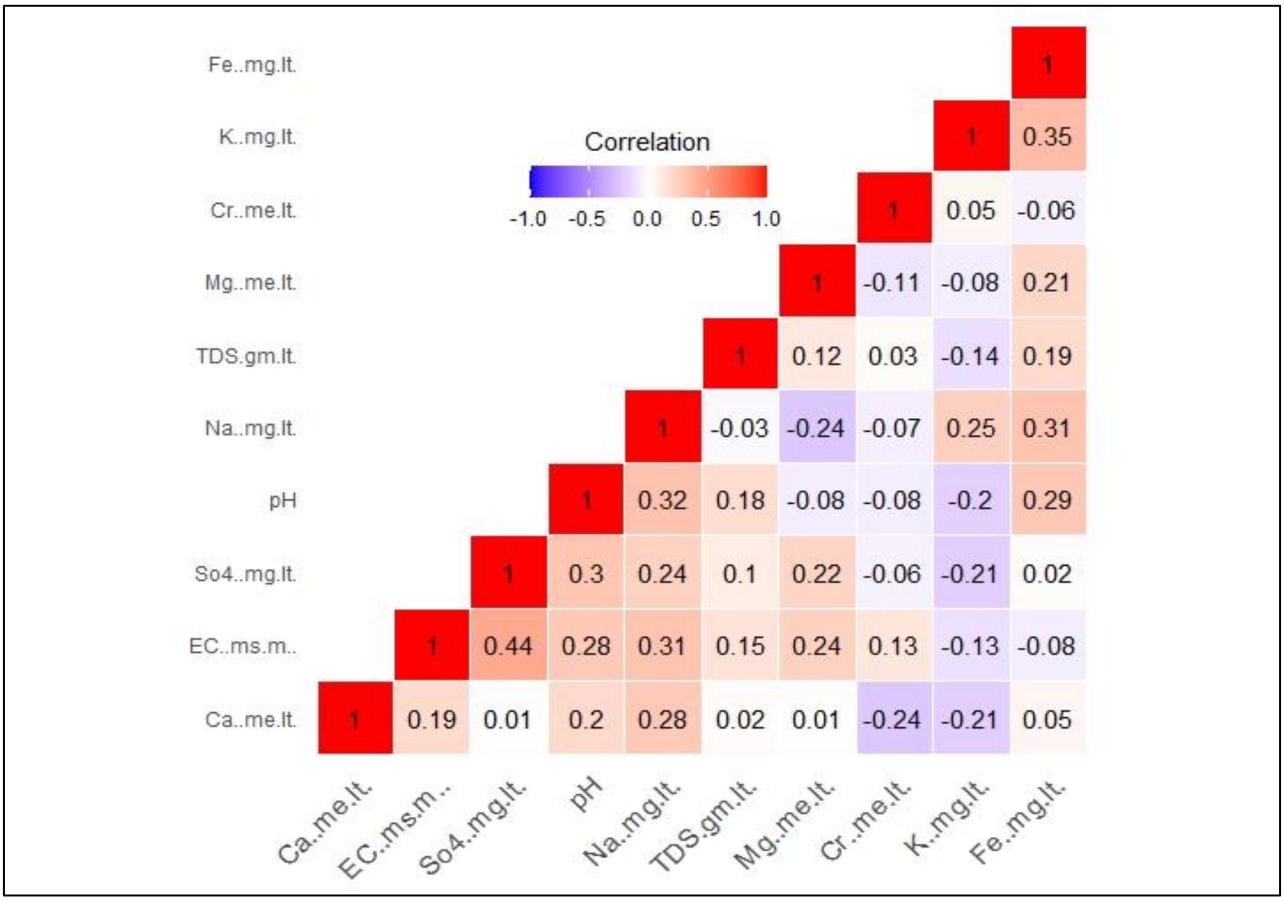

Fig 8: Correlation plot for waht

According to the p-value, high correlation has been seen between pH with Na i.e., 0.0308 and almost same with EC with NA (Table). Also, high significant correlation has been seen betweenSO4 with pH i.e., 0.0462 and with EC i.e., 0.0024. Moreover, a significant correlation has been seen between Fe and Na i.e., 0.0412 (Table).

Table 1 P-values of correlation plot $p<0.05$ shows high correlation over the study period (2019-2021)

	pH	EC..ms.m..	TDS.gm.lt.	Cr..me.lt.	Ca..me.lt.	Mg..me.lt.	Na..mg.lt.	K..mg.lt.	Fe..mg.lt.	So4..mg.lt.
pH	1	0.0661	0.2321	0.5829	0.1969	0.5996	0.0308	0.1958	0.0542	0.0461
EC..ms.m..	0.0661	1	0.314	0.3929	0.1997	0.1103	0.038	0.4096	0.6116	0.0024
TDS.gm.lt.	0.2321	0.314	1	0.8506	0.89	0.4309	0.8579	0.3626	0.2166	0.5204
Cr..me.lt.	0.5829	0.3929	0.8506	1	0.1131	0.4596	0.6344	0.7383	0.7015	0.6996
Ca..me.lt.	0.1969	0.1997	0.89	0.1131	1	0.9626	0.0672	0.1602	0.724	0.948
Mg..me.lt.	0.5996	0.1103	0.4309	0.4596	0.9626	1	0.1153	0.591	0.1749	0.1499
Na..mg.lt.	0.0308	0.038	0.8579	0.6344	0.0672	0.1153	1	0.0934	0.0412	0.1057
K..mg.lt.	0.1958	0.4096	0.3626	0.7383	0.1602	0.591	0.0934	1	0.0184	0.1636
Fe..mg.lt.	0.0542	0.6116	0.2166	0.7015	0.724	0.1749	0.0412	0.0184	1	0.8961
So4..mg.lt.	0.0461	0.0024	0.5204	0.6996	0.948	0.1499	0.1057	0.1636	0.8961	1

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