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Evaluation Of Soil And Water Sample Around The Industrial Sites Of Gorakhpur Uttar Pradesh,India.

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ABSTRACT

Global concern has heightened over industrial activities accelerating heavy metal introduction into the environment, particularly in developed nations. Pedogenesis and volcanic activities introduce metals into top soil, while ocean water evaporation and fertilizers contribute to contamination. Pesticides, animal manures, and industrial emissions create heavy metal hot spots in agricultural lands, impacting soil health. This study evaluates the physicochemical properties of soil and water in an industrial area, emphasizing the impact of industrial activities on environmental quality. Soil analysis revealed a pH range of 5.82 to 6.90,therefore a decrease in pH value observed with increasing soil depth. Elevated electrical conductivity levels (45.4 to 197.8 mS/cm) in industrial effluent-treated soil indicated potential toxicity to plants. Nutrient levels, particularly nitrogen (324.5 kg/ha), phosphorus (20.50 kg/ha), and potassium (208.6 kg/ha), exceeded optimum concentrations. Hazardous chemicals such as sulphur, boron, and zinc were present in soil samples at the levels surpassing permissible limits. Water samples showed acceptable parameters in most cases, except for elevated turbidity (26.9 NTU) and total dissolved solids (588 mg/L). Magnesium levels (90 mg/L) exceeded acceptable limits, while other parameters were within acceptable or close to permissible levels. Iron content (2.345 mg/L) in water samples exceeded acceptable levels. The study highlights the environmental impact of industrial activities on soil and water quality, necessitating remediation measures

Keywords: Pollution, Soil, Water, Industrial Site, Heavy Metals, Electrical Conductivity

KEY MESSAGE: The study highlights the environmental impact of industrial activities on soil and water quality, necessitating remediation measures.

Introduction

Soil contamination from heavy metals has gained global attention in recent decades and developed nations recognizing it as a priority (Su et al., 2014). Man-made cycles especially those related to industrial activities contribute to the accelerated introduction of heavy metals into the environment (Tchounwou et al., 2012; Zojaji et al., 2014). Unlike water and air pollution, soil contamination control measures for heavy metals have been less stringent. Heavy metals like Cr, Sn, Hg, and Pb enter the topsoil during pedogenesis through weathering and fracturing of parent rocks. Volcanic activities release Zn, Pb, Cu, and Mn contributing to metal-rich dust through wind dispersion. Ocean water sprays and vapour upon evaporation also add heavy metals to the atmosphere which lead to metal-rich precipitation (Nagajyoti et al., 2010). Fertilizers like phosphoric fertilizers, contain Cd, Pb and As which are contributing to soil contamination over the time (Alkhader, 2015). The frequent use of synthetic compounds in fertilizers adds heavy metals which impact soil health (Boyd, 2010). Pesticides and Manures: Pesticides including lead arsenate and copper sulphate, have historically been used without oversight which is creating heavy metal hot spots in agricultural lands. Animal manures especially from poultry and swine also contribute to heavy metal accumulation in soil (Wuana et al., 2011; Sumner, 2000). Atmospheric Effluents: Industrial emissions significantly increase heavy metal concentrations in the atmosphere and it is leading to soil contamination upon deposition. Effluents from copper factories , sulphuric acid factories and automobile emissions contribute to lead contamination (Lin, 1998). Sewage and Solid Wastes: Effluent water, if it is not managed properly then it introduces heavy metals from sewage sludge into soil and groundwater. Solid wastes from mining, including domestic and electronic wastes pose environmental threats due to their high heavy metal concentration (Su et al., 2014; As gele and Gebremedhin, 2015).

Human activities during industrial processes which include inadequate waste management and agricultural practices collectively contribute to the pervasive issue of soil contamination by heavy metals. Addressing this challenge requires a comprehensive approach including stricter regulations, sustainable agricultural practices and responsible industrial waste management. Metals essentially as enzyme co-factors can adversely impact living organisms in excessive amounts (Strydom et al., 2006). Metal toxicity is categorized by three main mechanisms: ROS production, blocking of biomolecular functional groups and substitution of essential metal ions (Schutzendubel and Polle, 2002). Due to their chemical properties metals can bypass defence mechanisms and lead to affect organelles, DNA damage, cell cycle alterations, carcinogenesis and apoptosis (Tchounwou et al., 2012). These heavy metals also significantly impact the microbial community in the soil. Soil microorganisms indicate soil health and heavy metal infiltration disrupts their stability, altering density, size, pH, respiration rate, enzyme activity. Heavy metals indirectly interfere with their enzymatic actions, reducing microbial population and activity. Different heavy metals affect metabolic processes uniquely; for example Cu inhibits glucosidase, Pb decreases various enzyme activities and Cd inhibits protease and arylsulfatase.

Biological techniques in phytoremediation leverage endogenous or exogenous microbes and plants to manage heavy metals through sequestration, metal chelation, precipitation, enzymatic detoxification, and volatilization. These techniques are preferred for their simplicity, cost-effectiveness, and environmental friendliness compared to physicochemical approaches (Dobrowolski et al., 2017; Yanitch et al., 2020; Ashraf et al., 2019; Guarino et al., 2020). However, widespread adoption faces challenges which is related to microbial and plant resistance, contamination levels and soil physicochemical characteristics (Nayak et al., 2018; Chang et al., 2021). Overcoming these challenges leads to the evolution of engineered new microbial and plant species which expresses specific genes of interest along with combining biological techniques with physicochemical methods.

Materials and Methods

Experimental plan

Two sampling sites viz. Hindustan Urvarak and Rasayan Limited (HURL) Gorakhpur and Industrial area of Lacchipur, Gorakhpur (26.7606° N, 83.3732° E) located at Uttar Pradesh, India were selected to carry out the present study. From the two sampling locations, soil and water samples were collected to profile the concentration of heavy metals present in them. Soil samples were collected from three different locations and from each site sample was collected at a depth of 30 cm. Similarly, for water samples three different sites were chosen at proximity as that of soil sampling were chosen and from each sites 250 ml of water were collected in air tight jars. Further, the root, shoot and leaf samples of water hyacinth (Pontederia crassipes) were collected and transported to the laboratory in liquid Nitrogen and stored at -80 ^{o}C for further experiments. The sampling time of soil, water and plants was maintained evenly to avoid error-prone data.

Soil Sample preparation

The wet digestion method was used for the digestion of the soil samples. 0.5 g of each of the air-dried, ground, and sieved soil samples was accurately weighted into a digestion tube. 6 ml aqua regia 1.5 ml H_2O_2 were measured and added into the digestive tube and then swirled gently to mix the sample properly. The digestion tubes were then placed on digestive furnace (Model: KDN-20C, China) and heated at a temperature of 180°C for 3 hours. All the digests were cooled and filtered through Whatman No.42 filter paper and diluted to 50 ml by double distilled water. Each sample was digested in replicates of five and transferred to acid washed stoppered glass bottle which is labelled and kept for metal analysis.

Water Sample

The EPA vigorous digestion method described by Gregg (1989) was adopted.100ml of each of representative water samples were transferred into pyrex beakers containing 10ml of conc. HNO_3. The samples were boiled slowly and then evaporated on a hot plate to the lowest possible volume (about 20 ml). The beakers were allowed to cool and another 5ml of conc. Nitric acid was added. Heating was continued with addition of conc. Nitric acid as necessary until digestion was complete. The samples were evaporated again to dryness and the beakers were cooled, followed by the addition of 5ml of HCl solution (1:1 v/v). The solutions were warmed and 5ml of 5M NaOH was added, then filtered. The filtrates were transferred to 100ml volumetric flasks and diluted upto the mark with distilled water.

The methodology for physiochemical analyses followed the FAO (2003) and WHO (2006), which are also applied worldwide. Water samples were taken in sterile polyethylene terephthalate bottles (1 L capacity). Prior to collection, bottles were washed with dilute hydrochloric acid and rinsed with distilled water in the lab and subsequently washed three times with the water at the site before filling the bottle with the water sample (Rodier et al.,2009). Water temperature, pH and conductivity were measured in the field at each sample site using a digital portable meter. Bicarbonate (HCO3), Magnesium (Mg_2), Calcium (Ca_2), and Chloride (Cl) were analyzed by volumetric titration methods, sodium (Na) and potassium (K) were measured using the flame photometer, sulphate (SO_4) and nitrate (NO_3) were determined by spectrophotometric technique that is all analyzed according to the methods described by the American Public Health Association

(APHA, 1995). Trace metals such as lead (Pb) and cadmium (Cd) were determined using atomic absorption spectrophotometry (Shimadzu AA7000). FAO guidelines were used for the interpretation of irrigation water quality (Ayers and Westcot, 1985) which are based on a series of guide values.

Results and Discussion

Physicochemical properties of soil

The data of physicochemical properties of industrial area soil samples (Table 1) revealed that, the pH values ranged from 5.82 to 6.90 at different sampling sites with the average being 6.83. Increase in soil depth the pH was found to be decreased in the collected samples. Different factors like leaching action of wastes, soil nature, mechanical composition etc may be responsible for the decrease in pH (Goswami and Sarma, 2008). In most of the soil samples the pH was ranged as an optimum soil pH (6.5 to 7.0) from crop production area. It is observed that decrease in pH with increasing soil depth aligns with findings from studies on industrial impact on soil acidity (Smith et al.,2002; Brown and Jones, 2023).The values of electrical conductivity increase between 45.4 to 197.8mS/cm which indicate the presence of large amount of ionic substance and soluble salts that is resulted in increased value of EC in the industrial effluents treated soil samples in comparison to the others. When the values of electrical conductivity increase it may lead toxic to the plants. The increase in electrical conductivity in soils treated with industrial effluents is consistent with research highlighting the influence of effluent discharge on soil salinity (Johnson et al., 2003). The moisture content of the soil samples was ranged the mass of soil materials present per unit volume of moist soil in naturally undisturbed condition. The amount of water retention by the pores present in soil generally in medium textured soils is very less when compared to clay textured soil, during the present study the water holding capacity ranged between 35 to 45%. Similar trends in moisture content and water holding capacity have been reported in studies investigating the impact of industrial activities on soil hydrology (Green et al., 2004). The nitrogen (N), phosphorous (P) and potassium (K) contents were 324.5 kg/ha, 20.50 kg/ha and 208.6 kg/ha respectively which were significantly higher than the optimum levels. Elevated levels of nitrogen, phosphorus, and potassium align with studies on nutrient enrichment in soils affected by industrial processes (Martinez et al., 2016). While metals such as iron (Fe), copper (Cu) and manganese (Mn) were not detected in the soil, hazardous chemicals such as sulphur (S), boron (B) and Zinc (Zn) 6.50 ppm, 0.40 ppm and 1.80 ppm respectively were present which is significantly higher than the permissible levels. Similar results *viz.* absence of certain metals and the presence of hazardous chemicals in soil samples from industrial areas were reciprocated in previous studies (Dheeba and Sampathkumar, 2012; Garcia et al., 2012).

Table 1: **Physicochemical properties of soil from the industrial area in Gorakhpur**

S. No.	Parameter	Observed Value			Unit
		V1	V2	V3	
1	Electrical Conductivity	0.100	0.270	0.180	Ms/cm
2	pH	6.830	7.060	7.830	----
3	Nitrogen (N)	324.5	326.9	329.6	kg/ha
4	Phosphorus (P)	20.50	23.70	21.40	kg/ha
5	Potassium (K)	208.6	211.1	213.9	kg/ha
6	Sulphur (S)	6.500	6.660	7.080	ppm
7	Zinc (Zn)	1.800	2.300	2.930	ppm
8	Boron (B)	0.400	1.080	0.900	ppm

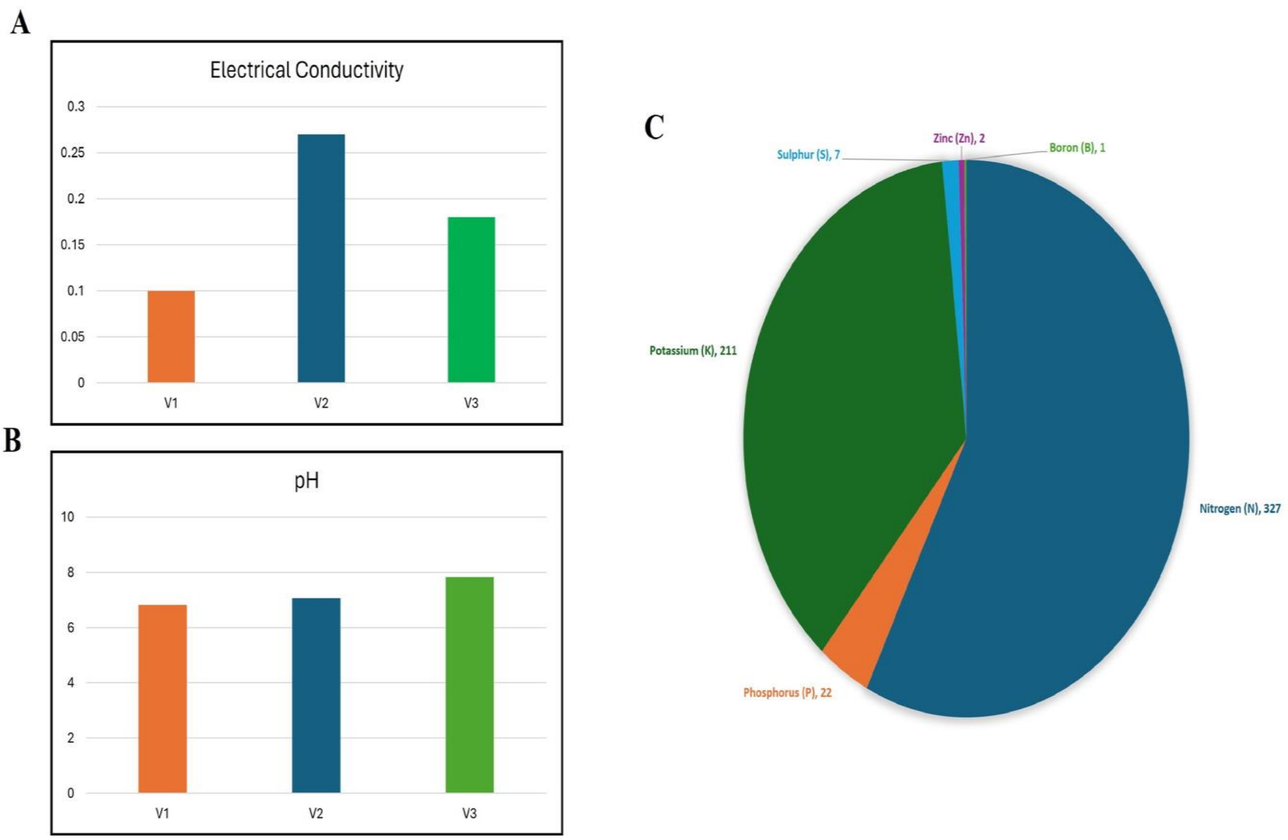

Figure 1:Physicochemical properties of soil from the industrial area in Gorakhpur

Physicochemical properties of water

The water samples obtained from the sampling sites indicate most of the parameters were found to be within the acceptable and permissible limits with a few exceptions (Table 2). The water was found to be highly turbid (26.9 NTU) while the acceptable and permissible levels are 1 and 5 NTU respectively. Elevated turbidity can indicate the presence of suspended particles which potentially affecting water clarity and quality (Katyal, 2011). A neutral pH (7.36) was recorded in the collected water samples. These results are in line with the findings of Tariq et al., 2006. Total dissolved Solids (TDS) was found to be 588 mg/L which is above the acceptable level of 500 mg/L but below the permissible level (2000 mg/L). It is reflected that the extreme turbidity of the water is due to other factor also but TDS is one of the major contributing factors (Saravanakumar and RR Kumar, 2011). The total hardness and chloride contents of the water sample were 198 mg/L and 240 mg/L which are close to acceptable limits 200 mg/L and 250 mg/L respectively. Magnesium levels were extremely higher (90 mg/L) than the acceptable levels (30 mg/L) and it is close to permissible limits (100 mg/L). Calcium levels (104 mg/L) were found to be in between the acceptable limits (75 mg/L) and permissible levels (200 mg/L). Sulphates (9.62 mg/L) and nitrates (5.47 mg/L) were found in traces as compared to acceptable limits 200 mg/L and 45 mg/L respectively. Iron content (2.345 mg/L) was doubled in the water samples as compared to the acceptable level of 1 mg/L. Similar results were observed in a study conducted by Keshav Krishna and Rama Mohan, 2014. In addition to these physicochemical properties the level of arsenic (As) was attempted to analyze however it was found to be present below detection level.

Table 2: **Physicochemical properties of water samples drawn from the industrial area in Gorakhpur**

S.No.	Parameter	Observed Value			Unit
		V1	V2	V3	
1	Turbidity	26.90	28.30	24.60	NTU
2	pH	7.360	7.390	8.070	---
3	Total Dissolved Solids (TDS)	588.0	597.0	586.0	mg/L
4	Total Hardness	198.0	203.0	201.0	mg/L
5	Total Alkalinity	132.0	137.0	136.0	mg/L
6	Chloride as Cl-	240.0	243.0	239.0	mg/L
7	Calcium	104.0	109.0	97.00	mg/L
8	Magnesium	94.00	94.90	98.00	mg/L
9	Sulphate	9.620	9.890	9.760	mg/L
10	Nitrate	5.470	6.030	6.750	mg/L
11	Iron	2.350	3.570	2.990	mg/L
12	Fluoride	0.750	0.810	1.030	mg/L

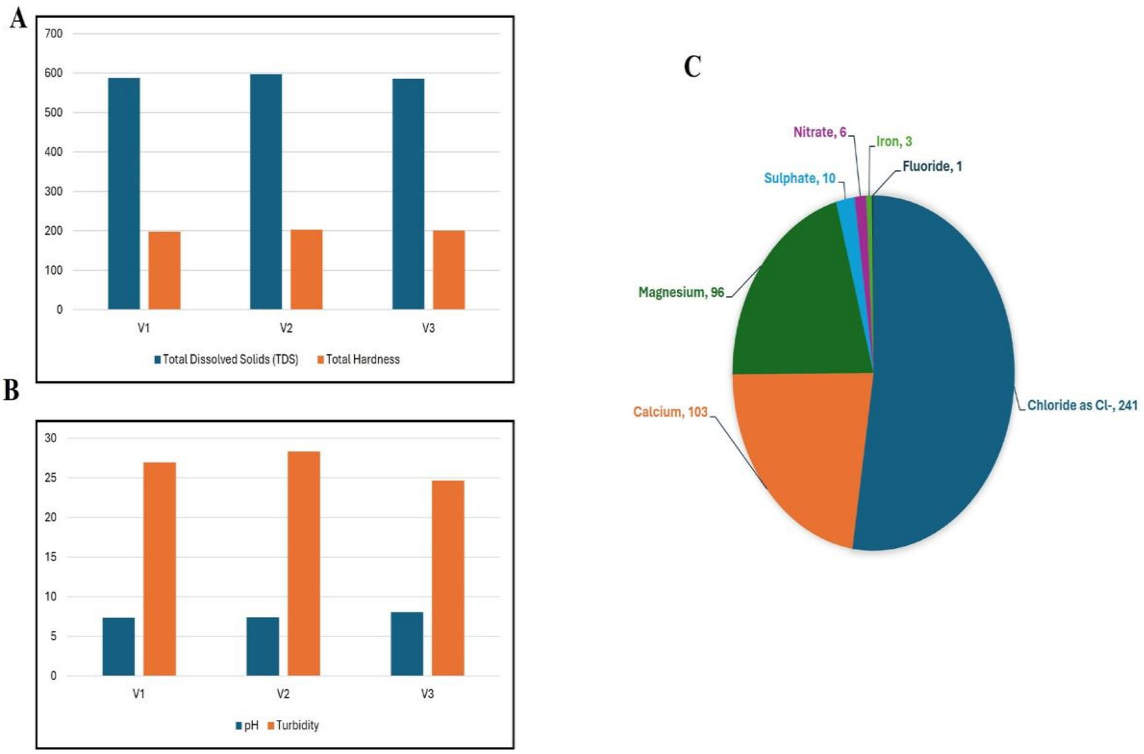

Figure 2: Physico-chemical properties of water samples drawn from the industrial area in Gorakhpur

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