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# Presence of hexavalent chromium due to industrial effluents in underground water resources affecting the health of rural population living near the ganga river basin

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## Abstract

Due to the numerous tanneries in Unnao, a significant amount of waste water is produced, and the effluents contain chromium, which can contaminate surface and subsurface water after seeping through the ground and becoming a powerful carcinogen. There are several types of chromium, with trivalent and hexavalent being the most common. When compared to Cr (VI), which has a high solubility and can quickly flow through groundwater and combine with it, Cr (III) has a low solubility. The samples used for this paper came from the Unnao district of Uttar Pradesh (India), and they were examined for pH, electrical conductivity, total chromium, total hexavalent chromium, and a number of other physicochemical parameters. One of the sites, Dharamkata, has a Cr (VI) value of 2070 g/l, which is highly effective for contaminating unlined channels and contaminating both surface and groundwater. Different bio-waste products were employed to remove Cr (VI) in order to address the issue. The diphenyl-carbazide technique and the Atomic Absorption Spectroscopy were used to measure the levels of Cr (VI) and total chromium. Hexavalent Chromium is highly oxidizing in nature and requires electron donor materials for reduction

**Keywords:** Ganga River Toxicity; Unnao Tannery; Pre Monsoon Sampling; Post Monsoon Sampling; Hexavalent Chromium Toxicity; Diphenyl Carbazide Method; AAS

## 1. Introduction

Our research studies have been completed for a portion of the district Unnao in the U.P. Hardoi District borders it on the north, and Raebareli and Lucknow District border it on the east. It is divided from the districts of Kanpur and Fatehpur by the Ganges River, which is found in the west. Geographically, it is located in the state of Uttar Pradesh's center. Due to its location in the vast Ganges plains, Unnao has extremely fertile land. Most of the soil is alluvial. The Ganges divides the Kanpur district from Unnao. Rivers Ganges in the west and Sai in the east round the district. The entire area located in the Ganges basin's Sai Sub-basin has flat landscape. Tubewells and the Sharda Canal network are used for district-wide irrigation. The district's area is being farmed in about 92% of the cases. The climate in District is subtropical. The Ganges with its tributaries Kalyani, Khar, Loni, and Marahai in the western portion of the district, and the Sai River in the eastern section, are the main drainage systems for the district [1]. All of these rivers have a permanent flow. A total of 3,00,000 hectares of net planted land are irrigated to an approximate 87% extent by shallow and moderately deep tubewells and the Sharda Canal network system. Surface water makes up 48% of irrigation while ground water makes up 52%. Agriculture is the district's principal economic driver. The District is divided into 6 Tehsils Unnao, Hasanganj, Safipur, Purwa, Bighapur & Bangarmau and 16 development Blocks namely – Ganj Moradabad, Bangarmau, Fatehpur Chaurasi, Safipur, Miyanganj, Auras, Hasanganj, Nawabganj, Purwa, Asoha, Hilauli, Bighapur, Sumerpur,Bichia, Sikandarpur Sirausi, Sikandarpur Karan. The topography of the Unnao industrial sector is significant and favourable for industrial needs. Currently, there are about 50 industries in the Unnao industrial region, mostly in the Leather and Textile sectors [2].

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## 2. Source identification

The Unnao region of India has many tanneries and allied industries. Industrial and agricultural wastes cause heavy metal pollution, which seeps into groundwater and affects human health. In this work, the amount of heavy metals in groundwater was measured at certain locations near industrial facilities in Unnao and possible sources of contamination, either anthropogenic or lithogenic, were identified. Groundwater samples were taken from 8 borehole locations selected based on depth and proximity to industry[2]. The data obtained from the sampling locations were interpreted using a multivariate statistical analysis approach, i.e. principal component analysis, cluster analysis and correlation analysis. The results of the multivariate analysis showed that cadmium, copper, manganese, nickel, lead and zinc were correlated with anthropogenic sources, while iron and chromium were associated with lithogenic sources. These results provide information on possible sources of heavy metal contamination and can serve as a model for assessment and monitoring of groundwater heavy metal contamination in other regions. This study analyzed a selection of heavy metals based on industries located in the study area, which may not provide complete information on the sources and availability of all heavy metals. Therefore, an extended survey of heavy metal fractions will be developed in future studies [3].

## 3. Sampling stations

For Collection of Water samples 8 Areas of Unnao District were identified where reports of chromium contamination were reported according to different reports and research papers. They are labelled as U1-U8 for easier identification.

**Table 1** List of Sampling stations of District Unnao

| Sr. No. | Sampling station | Sampling code |
|---|---|---|
| 1 | Asoha | U-1 |
| 2 | Sikanderpur Karan | U-2 |
| 3 | Hasanganj | U-3 |
| 4 | Sikanderpur Sirausi | U-4 |
| 5 | Miyanganj | U-5 |
| 6 | Purwa | U-6 |
| 7 | Hilauli | U-7 |
| 8 | Dharamkata(Before Bichia) | U-8 |

### 3.1. Methods And Process

Analysis Of various Physicochemical Parameters as Per Standard Procedures:

- **Pre and Post Monsoon Sampling**: - 40 litres of Water samples are collected from 8 sampling station for the performance of 12 physico-chemical parameter test of water quality assessment on pre and post monsoon water samples.
- **WQ Analysis of Pre and Post Monsoon Samples: -**Water quality refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water [4].

Different properties were analysed & compared during the course of the project.

### 3.2. Some of the properties analysed are as follows –

- Determination of Total Dissolved Solids
- Determination of Total Hardness
- Determination of pH
- Determination of Alkalinity

- Determination of Conductivity
- Determination of chloride content
- Determination of sulphate content
- Determination of Iron content
- Determination of Manganese content
- Determination of Fluoride content
- Determination of Nitrate content
- Determination of Chromium content

**Data Plotting: -** After the analysis of pre and post monsoon water sample the data will be plotted on the matrix sheet.

**Result Obtaining: -** From the plotted data the result will be obtain.

**Result Interpretation: -** From the obtain result the interpretation will be done and final conclusion will be extracted

### 3.3. Determination of Chromium Content

Many geographical regions have chromium in their drinking water supplies in the +3 and +6 oxidation states. Hexavalent Cr, which is a recognized human carcinogen that can be inhaled, is a source of public health worries. Cr(VI) can come from both human and natural sources and has a high mobility in the environment. Cr(VI) is more likely to be converted to the harmless form of Cr(III) in acidic environments with high organic content. In the presence of common minerals that contain Mn(IV) oxides, the opposite process of Cr(VI) production from Cr(III) also takes place[4]. There is insufficient epidemiological evidence to support an increased risk of stomach cancer from consuming Cr(VI). Animals exposed to Cr(VI) in their water exhibited linear and supralinear responses in the mouse small intestine, resulting in tumors in the gastrointestinal system. Chromate, the major form of Cr(VI) at neutral pH, is absorbed by every cell via sulphate channels and is nonenzymatically activated by ascorbate, which is present everywhere, and tiny thiols. Cr(VI) most frequently results in Cr-DNA adducts, which result in mutations and chromosomal breakage. New research suggests that the range of genomic rearrangements and gene expression profiles in cancers are determined by interactions between DNA damage and epigenetic modifications[4,5]. Strong evidence for the significance of DNA-reactive mutagenic mechanisms in the carcinogenic effects of Cr(VI) includes the extensive formation of DNA adducts, clear positivity in genotoxicity assays with high predictive values for carcinogenicity, the shape of tumor-dose responses in mice, and a biological signature of mutagenic carcinogens (multispecies, multisite, and trans-sex tumorigenic potency). According to bioavailability data and kinetic analysis, 10–20% of ingested low-dose Cr(VI) manages to avoid inactivation by the human stomach. A threshold in low-dose extrapolation of cancer risk for ingested Cr(VI) is argued against by the directly mutagenic mode of action and the incompleteness of gastric detoxification[5].

### 3.4. Chromium Content

Many industries utilize Cr (VI) in chromic acid and other forms. The chrome-plating industry uses chromic acid in the electro-plating process. Cr (VI) ions can be present in the waste water of this industry. Chromic acid is also added to the water used in industrial cooling towers to inhibit metal corrosion. The EPA recently banned Cr (VI) from use in 37,500 building roof cooling towers that leaked coolant into the air causing an estimated 20 cancer deaths. Cr (VI) is also found in paints, pigments, tanning agents, inks, fungicides and wood preservatives [6].

The maximum permissible level of Cr (VI) allowed to be released into waterways is 50 µg/L. The level in drinking water is much lower. A level higher than 3 µg/L is considered suggestive of industrial pollution [7].

In this experiment you will generate a calibration curve for detection of Cr (VI), solve a Cr (VI) pollution mystery and examine some methods by which industry can lower Cr (VI) concentration prior to releasing their waste water [8].

### 3.5. Environment contamination with chromium

Environmentally and commercially, Cr (0), Cr (III), and Cr (VI) are three thermodynamically stable Cr forms. Nearly all occurrences of Cr (0) are in its metallic state, most frequently as a constituent of iron-based alloys like stainless steel. Only Cr (VI), not Cr (0) or Cr (III), has been proven to cause cancer in lab animals and workers who have been exposed to it through their jobs. Numerous uses of Cr in the chemical industry, the production of dyes, wood preservation, leather tanning, chrome plating, fabrication of various alloys, and numerous more applications and products lead to environmental contamination in various ways [8]. The biggest volume product incorporating this metal is stainless steel, which has a maximum weight content of 20% Cr. The estimated occupational exposure of over 500,000 workers in the United States alone provides further evidence of the extent of Cr usage. Small particles containing Cr(VI) and

Cr(III) are produced by incineration and auto emissions, which exposes substantial portions of the population to low-level inhalation exposures and raises Cr levels in surface waters. The most severe instances of anthropogenic drinking water contamination in the United States were caused by cooling towers discharging hazardous Cr (VI)[8,9]. The inappropriate disposal of millions of tons of incompletely processed chromite ore resulted in another massive scale of environmental pollution with hexavalent Cr (VI). Cr is a significant contaminant in hundreds of the greatest toxic waste sites in the United States, sometimes known as Superfund sites. The oxidation of naturally occurring Cr (III) by Mn (III/IV) oxides in birnessite, a common mineral that coats weathered grains and fractures in serpentinites that are enriched with chromite [FeCr (III)2O4], may also be a contributing factor to the presence of Cr (VI) in drinking water. Asbolane and lithiophorite, two other Mn (IV) oxide-containing minerals, have also been linked to the synthesis of Cr (VI) from natural Cr (III), in addition to birnessite. Birnessite, cryptomelane, todorokite, and hausmannite, four Mn oxide-containing minerals, were examined, and it was discovered that birnessite had the greatest capacity to oxidize Cr (III) in a laboratory setting [9].

Cr (0)-containing products are mostly highly resistant to corrosion; however, slow oxidation of Cr-containing alloys can result in the limited release of soluble Cr (III) into soil and water. Cr (VI) is the most mobile form of chromium in the environment. Mobility of Cr (III) strongly depends on the acidity and Cr (III)-binding properties of soluble and insoluble components at the contamination sites. Cr (VI) and Cr (III) have different toxicological properties, and all public health concerns are focussed on the presence of Toxic Hexavalent Cr in drinking water. In 1991, the US-EPA set the present standard for Cr in drinking water (maximum contaminant level) at 100 μg/L, which does not distinguish between the presence of toxic Cr (VI) and nontoxic Cr (III). Considering long-standing public health concerns about Cr (VI), it is not clear why there are no requirements for specific monitoring of Cr (VI) levels. The analytical technologies for Chromium speciation and detection were not very sensitive until the mid-1980s, and reliable measurements of Cr (VI) at environmental levels typically required pre-concentration steps, which were more suitable for specialized academic laboratories than for routine monitoring. However, analytical methodologies and techniques for Cr (VI) underwent dramatic improvements a long time ago. The EPA's own Method 218.6 for the detection of hexavalent Cr was developed approximately 20 years ago and affords a reliable monitoring of Cr (VI) at 1 μg/L. This methodology is inexpensive and is based on a routine HPLC column separation of chromate anion followed by a colorimetric detection with diphenylcarbazide solution [9,10]. Essentially all analytical laboratories are equipped with HPLC and should be able to perform this type of Cr (VI) measurements at relatively low cost. Recent improvements of chromatographic conditions in the EPA's Method 218.6 allow the detection of Cr (VI) in drinking water at 3 μg/L (Application Update 179 from Dionex, Inc.). This sensitivity is more than sufficient to meet the most stringent regulations for Cr (VI), including those associated with the Public Health Goal of 20 μg/L in California. For many samples with very low Cr levels, Cr (VI) analyses by the modified Method 218.6 could be even more sensitive and informative than measurements of total Cr. Although the presence of Cr (VI) near municipal water reservoirs is the main reason for its monitoring in drinking water supplies, environmental contamination with Cr (III) can also generate Cr (VI) through oxidation reactions with water chlorination products, Ca and Mn oxides, and photo-oxidation. Overall, industrial activities associated with the direct release of Cr (VI) into the soil and water is the most important source of Cr (VI) contamination in drinking water [10].

## 4. Contaminated water collected from Sampling stations of District Unnao, India

Water sample collected from different underground sources of water supply in Unnao region of Uttar Pradesh India shows Different types of characteristics such as

- Slimy Nature
- Froth Appearances
- Yellow to Green Colour
- Foul Odor
- Bad Taste

It can be easily seen that water supply From Underground water resources such as Handpump tubewells and wells that water is not fit for Drinking but rural people in the Area are forced to use it for their daily purpose. Below here are some Pictures taken from contaminated water supply Areas of District Unnao, Uttar Pradesh India.

**Figure 1** This Picture is taken from Contaminated Water Supply in Unnao shows presence of neon colour water from handpump

**Figure 2** Froth like Appearance in water Supply of Sampling Area Bichia Unnao shows that the water supply is unfit for drinking

**Figure 3** Presence of Slimy Substance in Water Supply of Unnao which can be easily seen and felt while using the water from the contaminated sites of Bichia Unnao India Region

## 5. Structure Of Hexavalent Chromium

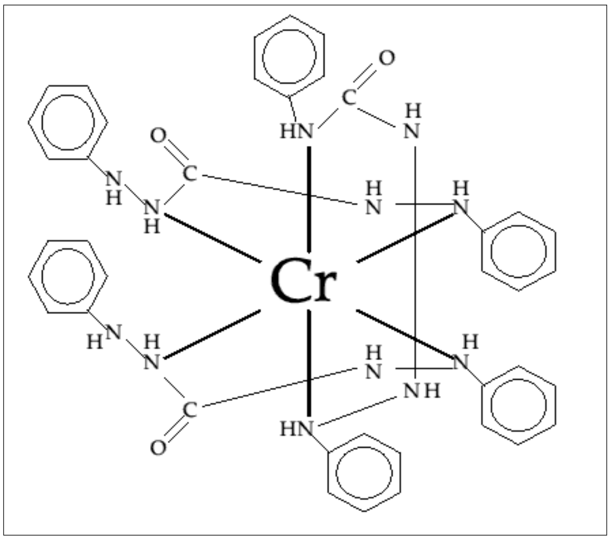

**Figure 4** This diagram shows the molecular structure of Hexavalent Chromium

Chromium in any chemical product that contains the element in the +6-oxidation state is known as hexavalent chromium (chromium (VI), Cr (VI), or chromium 6). Hexavalent chromium, specifically the salt sodium dichromate, is used to treat almost all chrome ore. All chromium-based materials depend on hexavalent chromium. Hexavalent chromium production in 1985 was somewhere between 136,000 and 150,000 tons. Chromium trioxide and different salts of chromate and dichromate are further hexavalent chromium compounds, among others. Hexavalent chromium is utilized in chromate conversion coatings, anti-corrosion products, wood preservation, textile colors, and many more specialized applications. Chromate pigments in dyes, paints, inks, and plastics, chromates used as anticorrosive agents to paints, primers, and other surface coatings, and chromic acid electroplated onto metal parts to produce a decorative or protective coating are just a few industrial applications for hexavalent chromium compounds. When performing "hot work" like welding on stainless steel or melting chromium metal, hexavalent chromium can occur. In these cases, the chromium is not initially hexavalent, but the process' high temperatures cause oxidation, which changes the chromium's state to hexavalent. All hexavalent chromium compounds are carcinogenic (IARC Group 1), poisonous (due to their oxidizing ability), and especially dangerous if inhaled since they can lead to lung cancer. Additionally, there have been confirmed links between chromium (VI) compound exposure and cancer of the nose and nasal sinuses. Hexavalent chromium exposure occurs in a variety of jobs. Workers who handle chromate-containing items and those who grind and/or weld stainless steel are known to be exposed in problematic ways. Employees exposed to hexavalent chromium are more likely to get lung cancer, asthma, or harm to their skin and nose epithelia. The Restriction of Hazardous Substances Directive primarily forbids the use of hexavalent chromium in electronic equipment throughout the European Union.

## 6. Methods of Sampling and Preservation

### 6.1. Preparation of Standards

Prepare six standard solutions in large test tubes which can accommodate 15-20 mL of solution.  Mix the quantities of Cr (VI).  Mix the quantities of Cr (VI) solution and 0.18 M sulfuric acid given in the table below to make solutions 1-6[11].

**Table 2** Test Tubes containing Cr and $H_2SO_4$

| **Solution #** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| Cr (VI), mL | 0.0 | 0.4 | 1.0 | 2.0 | 4.0 | 10.0 |
| $H_2SO_4$, mL | 10.0 | 9.6 | 9.0 | 8.0 | 6.0 | 0.0 |

Into each test tube pipet 0.5 mL of dipenylcarbazide solution. Mix the contents of the test tubes and let them stand for 5 minutes for color development.

Measure the absorbance of each sample at 540 nm and plot a standard curve. For the blank, use test tube 0. The absorptivity for the diphenylcarbazide-Cr (VI) complex is 40,000 $Lg^{-1}cm^{-1}$ a 540 nm.[4]

### 6.2. Determination of Chromium Concentration in Water Samples

Prepare a water sample for testing by placing 10.0 mL of water in a test tube. Test a sample of tap water and the sample labeled polluted water.

Add 12 drops pf 3 M sulfuric acid to the sample.

Pipet 0.5 mL of diphenyl-carbazide solution into the test tube and allow 5 minutes for color development.

Determine the amount of Cr (VI) present by measuring the absorbance of the sample at 540 nm.of Cr (VI)

### 6.3. Reducing Cr (VI) Levels for Disposal

#### *6.3.1. (A) Dilution Method*

The maximum permissible level of Cr (VI) allowed to be released in 50 µg/L. Assume that an industry has 100 L of Cr (VI) polluted water containing 0.127 mg/L of Cr (VI). Calculate how many liters of chromium-free water must be mixed with the polluted water so that it can be released.

#### *6.3.2. (B) Reduction Method*

Cr (VI) can be easily reduced to Cr (III). A maximum permissible level of Cr (III) of 1,000 µg/L may be released into natural waters.

Take a sample of the polluted water and add 5 drps of ascorbic acid solution (a mild reducing agent). Swirl the mixture and determine the Cr (VI) spectrophotometrically [9,11].

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## 7. Determination of Heavy Metal Concentration through Atomic Absorption Spectrometer

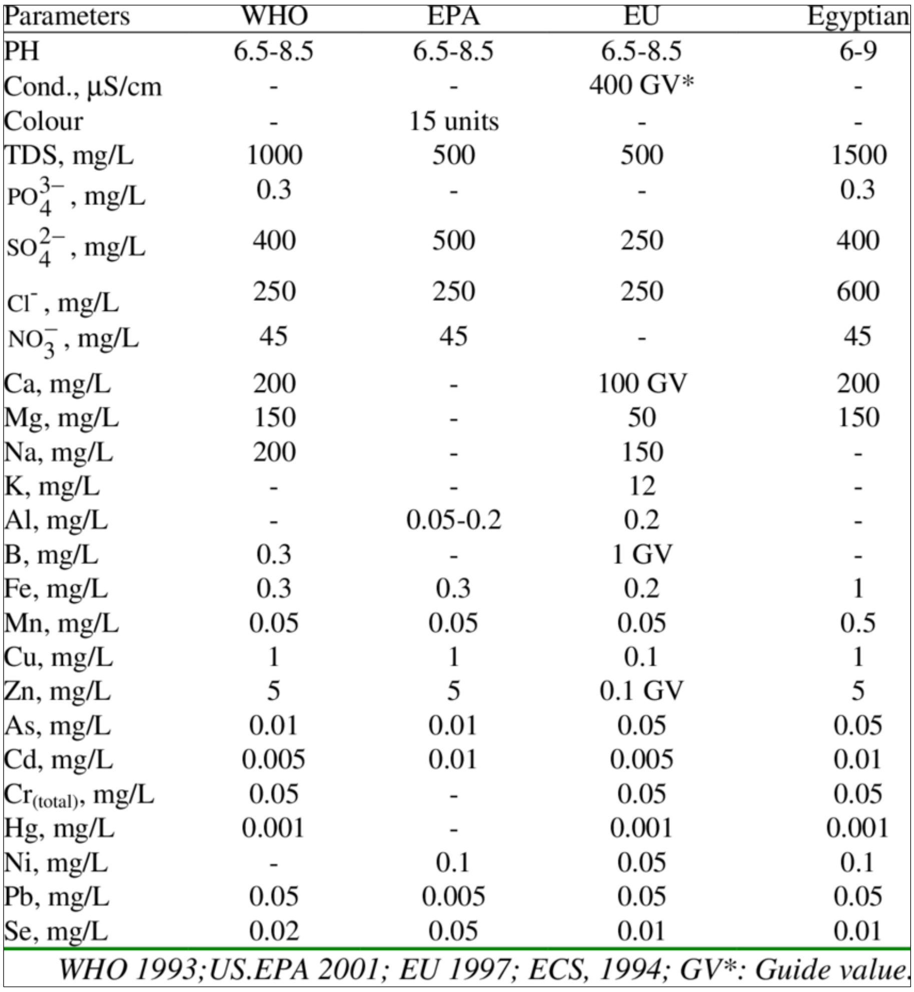
### 7.1. Digestion of sample

The APHA Standard technique (APHA 2005) was used to digest the water sample.

A 100 ml sample of water was collected in a beaker. HNO3 (5 ml) was added. Under fume hood conditions, the solution was put on the hot plate. Following the vaporization of the remaining 10 ml of the solution, 100 ml of deionized water was added to the volumetric flask and test is conducted as per standard protocols (APHA 2005) [12].

### 7.2. Guidelines for safe Drinking water

Potable and safe drinking water is very necessary for the health of living beings. Nationally and internationally various safe drinking limits are recognized and followed for intake of healthy water. BIS WHO USEPA and various organizations have conducted in-depth research and classifies toxic level of contaminants in drinking water [13].



| Parameters | WHO | EPA | EU | Egyptian |
|---|---|---|---|---|
| PH | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | 6-9 |
| Cond., µS/cm | - | - | 400 GV* | - |
| Colour | - | 15 units | - | - |
| TDS, mg/L | 1000 | 500 | 500 | 1500 |
| $PO_4^{3-}$, mg/L | 0.3 | - | - | 0.3 |
| $SO_4^{2-}$, mg/L | 400 | 500 | 250 | 400 |
| $Cl^-$, mg/L | 250 | 250 | 250 | 600 |
| $NO_3^-$, mg/L | 45 | 45 | - | 45 |
| Ca, mg/L | 200 | - | 100 GV | 200 |
| Mg, mg/L | 150 | - | 50 | 150 |
| Na, mg/L | 200 | - | 150 | - |
| K, mg/L | - | - | 12 | - |
| Al, mg/L | - | 0.05-0.2 | 0.2 | - |
| B, mg/L | 0.3 | - | 1 GV | - |
| Fe, mg/L | 0.3 | 0.3 | 0.2 | 1 |
| Mn, mg/L | 0.05 | 0.05 | 0.05 | 0.5 |
| Cu, mg/L | 1 | 1 | 0.1 | 1 |
| Zn, mg/L | 5 | 5 | 0.1 GV | 5 |
| As, mg/L | 0.01 | 0.01 | 0.05 | 0.05 |
| Cd, mg/L | 0.005 | 0.01 | 0.005 | 0.01 |
| $Cr_{(total)}$, mg/L | 0.05 | - | 0.05 | 0.05 |
| Hg, mg/L | 0.001 | - | 0.001 | 0.001 |
| Ni, mg/L | - | 0.1 | 0.05 | 0.1 |
| Pb, mg/L | 0.05 | 0.005 | 0.05 | 0.05 |
| Se, mg/L | 0.02 | 0.05 | 0.01 | 0.01 |

*WHO 1993;US.EPA 2001; EU 1997; ECS, 1994; GV*: Guide value.*

**Figure 5** This figure is of permissible limit of various drinking water parameters of different organisations

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## 8. Results

Various Parameters were tested in Laboratory Under APHA CODE Like Ph, Electrical Conductivity, Total Dissolved Solids, Total Hardness, chloride, fluoride, nitrate, Iron Sulphate, Magnesium and Specifically Chromium.

Each Sampling stations consisted of 5 samples and testing were conducted. Results are recorded in tables given Below according to statistical analysis:

### 8.1. Pre Monsoon Results

**Table 3** This table shows the results of water samples collected from Unnao Region, India ,along Ganga River Basin Before Monsoon

| S. No. | Code | Ph | EC | TDS | TH | Alkalinity | Cl | F | $NO_3$ | Fe | $SO_4$ | Mg | Cr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| 1 | U-1 | 8.19 | 692 | 1057 | 281 | 454 | 256 | 0.66 | 6.1 | 0.52 | 380 | 20 | 0 |
| 2 | U-2 | 8.19 | 520 | 420.65 | 238 | 250 | 21.72 | 0.72 | 4.77 | 0.52 | 7.89 | 32.9 | 0 |
| 3 | U-3 | 7.2 | 489 | 281 | 205 | 391 | 40.1 | 0.43 | 10 | 0.08 | 30 | 34 | 0.19 |
| 4 | U-4 | 8.04 | 632 | 478 | 168 | 392 | 219 | 1.09 | 3.76 | 1.12 | 65.73 | 30.12 | 0.10 |
| 5 | U-5 | 8.32 | 522 | 403.7 | 211 | 249 | 41.39 | 0.12 | 36 | 0.19 | 51.09 | 35 | 0.011 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | U-6 | 8.24 | 947 | 502.7 | 253.79 | 422 | 179.26 | 1.09 | 27 | 11 | 37.26 | 25 | 0.01 |
| 7 | U-7 | 8.40 | 852 | 412 | 201.2 | 252 | 38 | 0.68 | 3.23 | 0.37 | 26 | 37 | 0.0023 |
| 8 | U-8 | 8.37 | 583.4 | 452.3 | 251 | 370 | 62 | 0.7 | 19.01 | 0.55 | 19.23 | 47.92 | 2.07 |

### 8.2. Post monsoon Results

**Table 4** This table shows the results of testing done on water samples collected from Unnao region India After Monsoon.

| S. No. | Code | pH | EC | TDS | TH | Alkalinity | Cl | F | NO₃ | Fe | SO₄ | Mg | Cr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | U-1 | 7.92 | 701 | 1129 | 255 | 496 | 240 | 0.79 | 5.9 | 0.56 | 386 | 19.43 | 0.01 |
| 2 | U-2 | 7.90 | 526 | 426 | 206.2 | 269 | 28.8 | 0.79 | 4.52 | 0.69 | 7.01 | 37.23 | 0 |
| 3 | U-3 | 6.9 | 462.3 | 289 | 201.9 | 399 | 42.43 | 0.40 | 9.92 | 0.07 | 31.9 | 35 | 0.21 |
| 4 | U-4 | 7.79 | 647 | 459 | 179 | 408.9 | 223.7 | 2.03 | 3.42 | 2.31 | 72.23 | 32.33 | 0.17 |
| 5 | U-5 | 7.97 | 567 | 412.3 | 216 | 253 | 38.02 | 0.29 | 28.29 | 0.27 | 46.03 | 36.29 | 0.023 |
| 6 | U-6 | 7.69 | 963 | 511.02 | 247.63 | 436.28 | 173.97 | 1.032 | 31.02 | 13 | 43.82 | 27 | 0.0112 |
| 7 | U-7 | 7.82 | 857 | 392 | 198.03 | 273.79 | 43.27 | 0.81 | 3.72 | 0.39 | 29.37 | 41 | 0.0102 |
| 8 | U-8 | 7.8 | 578.9 | 459.37 | 247 | 382 | 69.23 | 1.03 | 23.36 | 0.79 | 28.29 | 41.02 | 2.10 |

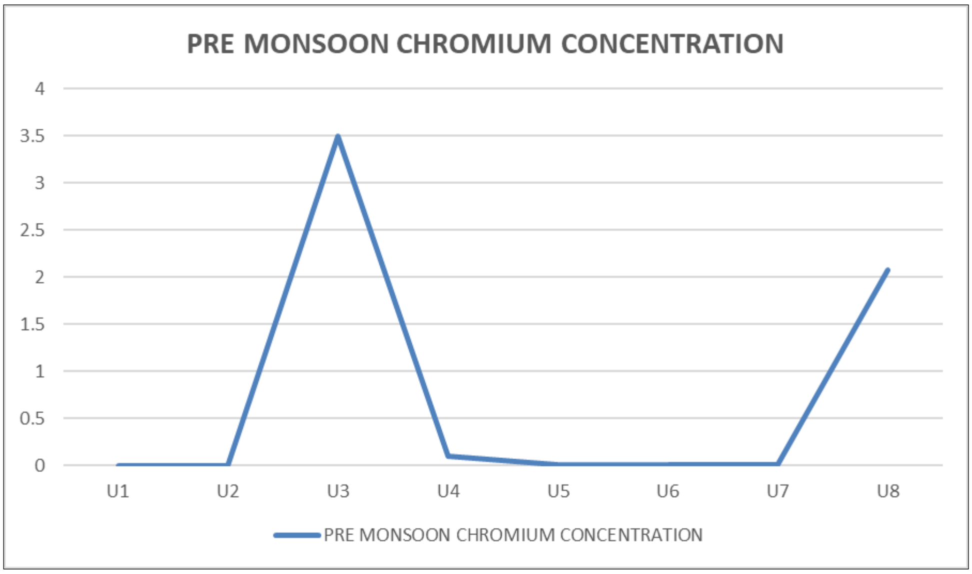

**Figure 6** Graphical representation of Data of pre monsoon concentration at various sampling stations

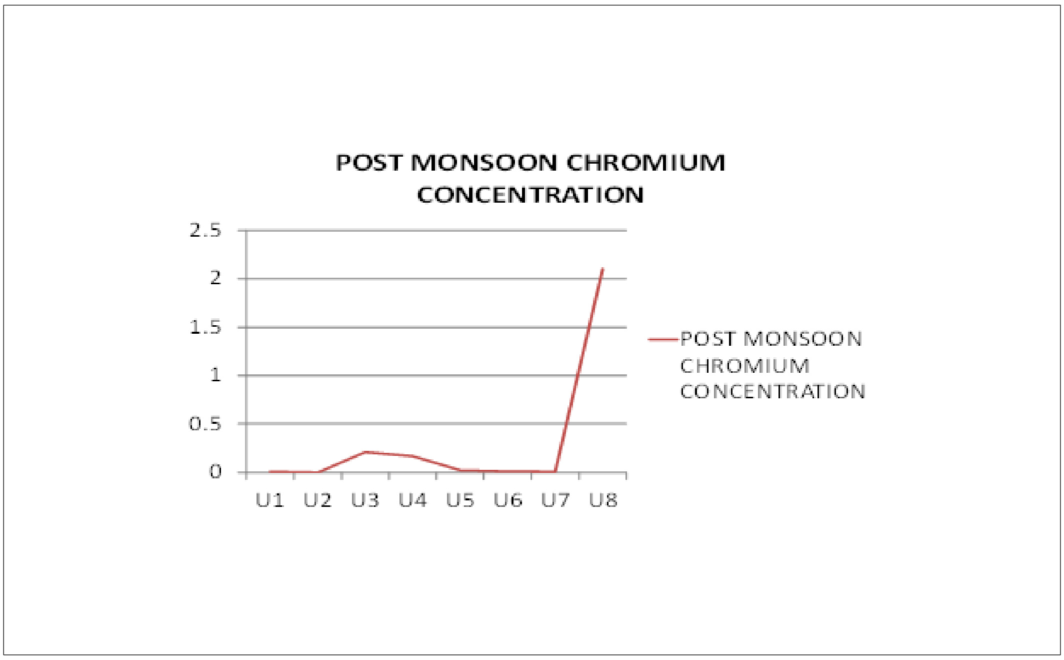

**Figure 7** Graphical representation of Data of post monsoon concentration at various sampling stations

## 9. Discussion

Analytical data of water samples collected during pre-monsoon and post-monsoon are collected in table1and table 2[13].

The quality of groundwater of study area was assessed as per standard specification given by BIS 2012. The variation of 12 physico-chemical parameters namely pH, $Cl^-$, $NO_3^-$, $F^-$, $SO_4^{2-}$, TH, $Ca^{2+}$, $Mg^{2+}$, TDS, TA, Fe and Cr in different samples taken from each sampling station of Unnao district. All the sampling were done pre-monsoon and then all the parameter were analysed in the laboratory and the at post monsoon sampling were done and the samples were analysed and it was observed that there is a little decrease in the pH values from pre monsoon to post monsoon while alkalinity of the samples also shows the increment after monsoon [14].

TDS shows the increase in concentration after monsoon and especially at the sampling station U1 and as far as chromium is concerned at the sampling station U3 U4 and U8 i.e. near Dharamkata PS Dahi Before Bichia it is exceeding the limits before and after monsoon and since chromium is a heavy metal a proper water treatment is strongly recommended for this place [15].

Other chemicals such as Cl, F, $NO_3$, Fe, $SO_4$ & Mg are found to be in permissible limit but have there is a decrease in the concentration after the monsoon like in Mg at U8 and in $NO_3$ & $SO_4$ at U5 and in $NO_3$, Fe, F at U3[16,17].

Due to Increase in Chromium concentration Local Population Has complaints of Digestive and Respiratory Disorders. Some cases have reported of Skin Lesions and Infection in the Body.

Hence this increase in the concentration of Chromium at three sampling stations from permissible limit, a proper water treatment is required and there is a large availability of **Azotobacteria** Microbes which is universally present in Soil and is responsible for Nitrogen Fixation in the study area so it becomes easy to Use its Microbial system to bioremediate the Toxic Hexavalent Chromium from the Ground Water Resources.

## 10. Conclusion

Water quality Assessment of various sampling stations of Unnao district shows that hexavalent chromium concentration of some places exceeds permissible limits according to the standard ranges. This increase in chromium concentration has negative impact on the health of flora and fauna which can lead to severe consequences. Hence some easier, environment friendly and natural solution to bioremediate the toxic elements is required to provide sustainable environment for the development of flora and fauna which is efficient to protect the health of living beings and is in favour of sustainable agriculture too.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No Conflict of Interest to be disclosed.

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