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Scrutinize of Physicochemical Parameters and Heavy Metals in Industrial Waste Water of Agra District and Alleviation Measures of Their Venomous Effect

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Abstract:- With the increasing industrialization and urbanization, the vastness of waste is steadily increasing day by day. This is mostly passed on to the main sewage system and falls on the land, from there this wastewater is released directly into the river. This increases the turbidity of the river and the people living there are affected by it. Thus the consumption of contaminated water in animals and humans causes many metabolic disorders. Levels of Heavy metals, concentration of Alkali and Alkaline earth metals were measured in industrial wastewater, for this water samples were collected from ten different points of Agra district of Uttar Pradesh. Some physicochemical parameters of wastewater were also analyzed like pH, EC, TDS, Total Hardness, COD, Chlorides. The TDS was found to be in the range of 409 to 4290 ppm; whereas the COD was 68 to 772 mg/l. In addition, the minimum value of Chloride was 170mg/l and the maximum value was 1356.1 mg/l. Furthermore, the hardness was 350 to 2205 mg/l as $CaCO_3$. In contrast, Heavy metals were investigated and compared with the Standard limits of water. The concentration of all the physiochemical properties and levels of heavy metals in industrial wastewater is higher than standard parameters given by WHO, USEPA, ICMR, BIS & CPCB. These effluences are not suitable for drinking and irrigation purposes. This investigation reflects a very squalid quality of water in this area. The consequence of the existing study points out the need to take inexorable steps before discharging the wastewater into the main drainage or river and the health risk status of wastewater for residents and aquatic living beings.

Keywords:- *Contaminated Water, Industrialization, Heavy Metals, Accumulation, Physio-Chemical Properties.*

I. INTRODUCTION

Due to the increase in population human activities demand new things to survive which in turn leads to industries creating new chemicals, materials, and enormous quantities of energy, which further exploit natural resources and create a large amount of waste leading to environmental pollution. In Agra city, various kinds of industries are present which include the automobile industry, major leather, and shoe industry [1-2], chemical industry, textile, paper, and food processing industries. These industries are providing employment, boosting the economical growth of local people. However, these industries discharge their waste without treatment directly into the water body[3-4-5]. It has been seen that this water is used by farmers for irrigation [6]and adversely affects the livelihood and day-to-day life of local peoples of the city. Most industries do not have proper effuse wastewater treatment plans and many do have a plan but have not implemented it because of cost. Industries effuse wastewater containing chemicals and other harmful bi-products. Freshwater is limited on the earth. It is incumbent for human existence, industry, and agriculture. Without freshwater of ample quantity and quality, sustainable development will not possible[7]. We have conducted a study on industries of Agra city to assess physicochemical parameters[8-9] and heavy metals concentration in waste water[10-11]. Generally, the characteristic of wastewater is especially represented by some physical and chemical properties such as PH, COD, EC, Alkalinity, Acidity, TDS, Hardness, and chlorides, The other minority substances such as heavy metals, sodium, potassium, and lithium ions. Heavy metal is defined as the metallic element that has a relatively high density compared to water.[12] Chromium (Cr.), Cadmium (Cd), Mercury (Hg), Lead (Pb), Nickel (Ni), and Thallium (Tl) are perilous in combined or uncombined form. These metals are highly soluble and therefore, they can be easily absorbed by a living organism. Hence, they enter our food chain and start to accumulate in our body organs like kidneys and liver [13], etc., and do not pass out after adsorption kidney failure and bone malformation be common problems due to heavy Cd intake. The level of toxicity of some selected heavy metals for humans follows the sequence Co<Al<Cr<Pb< Ni<Zn<Cu<Cd<Hg.[14] Allowable safe limits of Heavy metals in food samples are associated with low health risks in humans. According to USEPA's regulatory limit of Hg for drinking water is 2ppm. The WHO recommended safe limits of Hg in wastewater and soil for agriculture are 0.001 and 0.005 ppm. Some heavy metals, such as Cu and Zn, have known function as micronutrients in plants, they become toxic at high levels. High accumulation of metals affects both the growth and metabolism of plants [15]. These phototoxic effects of heavy metals depend on metal concentration, plant species, pH, and other factors in soil [16]. It has been reported that Co, Cu, Cr, Fe, Mn, Mo, Ni, Se, Zn, are essential nutrients that are required for various biochemical and physiological functions. The inadequate supply of these micronutrients results in a variety of deficiency diseases or syndrome. Prior studies include the determination of physicochemical properties of the wastewater effluents, Phenolic group, and chlorine pesticide in their sewage sludge, from the physicochemical quality parameters reported by [17]. Thanks to the atomic spectroscopic technique given by Bunsen and Kirchhoff in 1860 that an instrument was developed called flame photometer which is used in inorganic analysis to determine

the concentration of certain metals ions among them sodium, potassium, calcium, and lithium. In this technique, the sample solution is sprinkled in flame and allowed to vaporize after vaporization, solid metal elements convert into gaseous metal ions. Due to the thermal heat of the flame, gaseous metal atoms get excited and start emitting radiation[18]. The intensity of the characteristic wavelength produced by the atoms in a sample is directly proportional to its concentration.

Table 1|Peculiarity wavelength of the elements [18].

S.NO	Element	Wavelength(nm)	Flame colour
1	Potassium(k)	766	Violet
2	Lithium(Li)	670	Red(carmine)
3	Calcium(Ca)	622	Orange
4	Sodium(Na)	589	Yellow

Remediation is required to avoid heavy metals mobilization into the environmental segment [19] and facilitate their extraction because the environment is facing manifold malefic effects and urgent action is required to both prevent pollutants from reaching the biosphere and to facilitate the removal of pollutants that have already contaminated the biosphere to restore the proper functioning of biogeochemical cycle. thus various convenient methods for the removal of the noxious effect of heavy metals from the contaminated water. which includes Precipitation, Ion exchange method, Microbial genetic engineering, Bioadsorbent [20]. These techniques are environmentally friendly and more dominant in the revamp of contaminated water.

➢ *Broad Outline of This Work:*

- To ascertain the physicochemical properties of polluting water.
- To find out the content of heavy metals in the wastewater.
- To suggest **suitable remedial measures to cut back toxicities of heavy metals.**

II. MATERIAL AND METHODS

➢ *Representation of the Study Area:*

The present investigation was undertaken in the adjoining areas of Agra city. This is situated on the banks of the Yamuna River in the Uttar Pradesh State of India. It is located at a distance of about 210 Km. from New Delhi which is the capital city of the Indian Republic and in the West of the state capital Lucknow 340 Km. In geographical terms, the exact location of the city of Agra is 27.18^0 N and 78.02^0East. In this city 3 major industrial areas are present. Which is located at Sikandra industrial area, Foundry Nagar Industrial area, and Nunhai Industrial area.

Fig 1 Geographical location of the study area[21-22].

The drain wise and sector-wise distribution of industries and their estimated treated effluents discharge and details of CETP are given in the Table-2:

Table-2| Summary of Drains.[22]

S. No	District	No. of Drains	Type of Drains	Status of Drains			Sewage Discharge (MLD)			Total Discharge in the River (MLD)
			Domestic	Tapped	Untapped	Partially Tapped	Treated	Untreated	Total	
1	Agra	90	86-Domestic 4-Mixed	16	61	13	220.75	57.85	278.60	57.85

This implies that more wastewater comes from various industries of Agra city and is discharged to the Surrounding through the wastewater channel. This wastewater is used as the source of irrigation water by the farmers around this industrial area.

➢ *Apparatus & Equipment*

The instrument used for this investigation is Atomic Absorption Spectroscopy (Avanta AAS manufactured by GBC Scientific Equipment Ltd.), Microprocessor based Flame photometer 128(manufactured by Systronics India Ltd), pH-EC-TDS meters is used for the determination of soil/water pH and conductivity., Hot plate, Hot air oven. The common laboratory apparatus used during the investigation include measuring cylinders, volumetric flask, Beakers, Pipette, funnel, Conical Flask Spatula, Gloves, Reflux condenser, Filter paper, etc.

➢ *Chemicals, Reagent & Standard Solution:*

- Deionized water and Distilled water (D.W) are used for all preparation and dilution purposes.
- $HN0_3$, KCl, H_2SO_4, H_2O_2, and HCl are used for digestion.
- $AgNO_3$, K_2CrO_4, $AgSO_4$, NaCl (AR), KCl(AR), Li_2CO_3, and some indicators like Phenolphthalein, Methyl orange, Ferroin indicator are used for a different experiment.
- pH4 and 7 Buffers were used for pH meter Calibration and KCl was used for conductivity meter calibration. The stock solution of 1000 ppm was prepared for the selected heavy metals.

➢ *Water Sampling and Preparation:*

Only ten out of many sites are selected for this investigation. The wastewater samples are collected from five sites located near **Sikandra Industrial Area (SIA)** and three samples are collected from **Foundry Nagar Industrial Area (FNIA).** Measuring points for the sampling are referred to as S1 to S10. Two groundwater samples(S8-S9) are taken from randomly selected premises in the study area. Waste samples are collected from the discharge point of SIA referred to as S1, 450m away from the discharge point referred to as S2, and S3, S4 and S5 are taken from the discharge point of other sectors of SIA. S6, S7, and S10 were collected from three different points in (FNIA). These 10 samples were instantly acidified with 1 ml nitric Acid, for later analysis of metal concentration. The purpose of the acid is to keep the metals in solution and to avoid adsorption to the container water. Samples are collected and then transferred to the college laboratory for further investigation.

➢ *Physical and chemical properties:*

Physico-chemical parameters of wastewater such as **pH, TDS, Chloride, EC, Total Hardness, Acidity, Alkalinity, COD were determined by adopting standard procedure given by APHA[23] and guide manual[24].**

➢ *Preparation of standard solution for Flame Photometry:*

According to **the Bureau of Indian Standards**, the solution was prepared as follows [25] Take the weight 2.542 grams of analytical reagent quality of sodium chloride (NaCl) in a 1000ml volumetric flask. Simultaneously, weight 1.909 of potassium chloride (KCl) and transfer it into the volumetric flask through the funnel; together, take the weight 5.32 gram of lithium carbonate (Li_2CO_3) in 1000ml volumetric flask, add deionized water to the flask, dissolve the crystals and make up the solution to the mark with deionized water. The stock solution contains 1000ppm of sodium, potassium, and lithium respectively. From this stock standard solution 100, 80, 60, 40, 20ppm solution of lower concentration was prepared for Na & K. For lithium 50, 40, 30, 20, 10ppm standard solution was prepared. Aspirate distilled water and calibrate with standard solution after this emission was noted for all standard solutions. Lastly, the water sample solution was aspirated and emissions were noted.

➢ *Determination of Heavy metals by AAS:*

Before analysis for Heavy metals, the effluents and water sample are filtered through Whatman filter paper (No541) into 100 ml of the prewashed plastic bottle. After that samples are kept at room temp. until analysis. Concentration is often expressed as mg/L or ppm. A prepared standard solution of Heavy metals (such as Cr, Cd, Cu, Mn, Pb) for comparison and the absorbance of each sample was measured. The prepared standard concentration and the corresponding correlation coefficients of the calibration curve for each metal in wastewater are presented in **Table-3**.

Table-3| Concentrations of the working standard solutions and Coefficient of determination of the calibration curve for analysis of wastewater samples.

Element	Concentration (mg/L)	Co-relation Coefficient(R^2)
Cd	0.5,1.0,1.5 and 2.0	0.995
Cr	0.5,1.0,2.0 and 3.0	0.993
Cu	0.25,0.5,0.72 and 1.0	0.994
Mn	0.1, 0.2, 0.4 and 0.8	0.995
Pb	1,2,3 and 4	0.997

The correlation coefficient (R^2) values that are closer to '1' indicate that there is a strong relationship between the variables being correlated. Whereas closer to 0 indicates that there is no linear relationship. The correlation coefficient of metals is lie in the range between 0.993 to 0.997 which indicates a strong relationship. The sample had to be diluted many folds to keep the result in the analytical range. The heavy metals concentrations in all samples are determined by AAS (Atomic Absorption Spectrometer).

III. RESULTS AND DISCUSSION

It is evident from Table-5 that the ranges for Physico-chemical properties of industrial wastewater were revealed that there was wide variation in all the properties (is discussed below briefly).

➢ *Physical Characteristics:*

For the analysis of the wastewater sample two test will be performed which are as follow:

1. Physical Test
2. Chemical Test

The results of various physical/chemical tests are shown below and discussed in brief. The colour and odour of different wastewater samples confirm that the sample was collected from a contaminated zone. The results of the color and odor parameters of the wastewater sample investigated in the present study are present in Table-(4).

Table-4| Physical properties (Colour and odour) of samples.

Sample	Colour	Odour
Sample 1	Greenish	Grassy or fishy odour
Sample 2	Blackish	Very pungent odour
Sample 3	Grayish	slight pungent odour
Sample 4	Light yellow	Malodor smell
Sample 5	Lemon Yellow	Mild pungent odour
Sample 6	Pale yellow	Rotten egg
Sample 7	Light greenish	Pungent odour
Sample 8	Slight blue tint	No odour
Sample 9	Light blue	No odour
Sample 10	Off black	Very Pungent odour

Table-5| Outcomes of the Physio-chemical parameter of polluting wastewater.

Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
pH	**6.06**	**6.07**	**8.33**	**7.6**	**5.55**	**4.88**	**5.85**	**8.45**	**8.01**	**3.8**
TDS (ppm)	**409**	**767**	**1690**	**1700**	**1360**	**1490**	**1050**	**3410**	**945**	**4290**
Chlorides(mg/l)	**667.4**	**170**	**610.6**	**1341.9**	**397.6**	**660.3**	**291.1**	**1356.1**	**220.1**	**426.1**
Conductance	**120**	**420**	**470**	**360**	**260**	**300**	**210**	**200**	**120**	**310**
Total Hardness(mg/l)	**825**	**430**	**425**	**363**	**550**	**700**	**500**	**1700**	**350**	**2205**
Acidity(mg/l)	**540**	**250**	**90**	**280**	**100**	**390**	**170**	**40**	**0**	**810**
COD (mg/l)	**472**	**428**	**504**	**536**	**452**	**772**	**612**	**556**	**68**	**342**
Temperature ^{o} C	**19.1**	**19.8**	**19.3**	**19.1**	**20.1**	**23**	**23.8**	**24.6**	**24**	**21.7**

Table-6| Correlation matrix for various water quality parameters.

	Temp	*pH*	*EC*	*TDS*	*Chloride*	*Hardness*	*Alkalinity*	*Acidity*	*COD*
Temp	1								
pH	0.159059913	1							
EC	-0.3086098	-0.0010743	1						
TDS	-0.28185599	-0.16019617	0.142042864	1					
Chloride	0.092395743	0.442880617	0.028185889	0.36522039	1				
Hardness	-0.3036188	-0.35007366	-0.14164739	0.88372136	0.237725638	1			
Alkalinity	0.143815128	0.068434173	0.50761588	-0.25652514	-0.33492051	-0.51883502	1		
Acidity	-0.6707464	-0.72309512	0.033114725	0.36627102	-0.06767269	0.57680043	-0.394565048	1	
COD	0.374689157	-0.19394488	0.284410709	0.00260707	0.405352784	-0.01529353	0.041395333	0.02664751	1

*** Correlate with Figure-18 and Table -9**

➢ *pH:*

pH is the most essential parameter for measuring the wastewater sample. pH tells a lot about water. It tells that the pH value less than 6 indicates the septic condition and corrosiveness in nature and more than 8.5 causes some metal ions to precipitate.

According to Table-5, the maximum value of pH is reported in sample 8, and the least value is reported in sample-10 and after that, in the rest of the sample, bring the value of pH between maximum to minimum. These variations occurred in the pH values due to changes in the values of CO_2, Carbonate, and Bicarbonate in water. The result of our different samples is given in **Figure-2.**

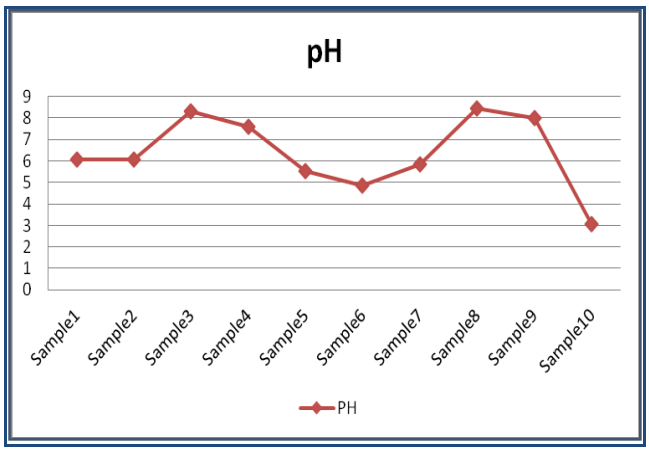


Fig 2- showing the pH graph.

➢ *Total Dissolve Solid (TDS)*

The total dissolved solid of the wastewater samples varied from 409 to 4290ppm(Table-C). TDS concentration of all the water samples (except sample 1) surpassed the maximum allowable limit (500ppm) of WHO [26]. It can be toxic to aquatic life by changing the composition of water.

The TDS of the wastewater samples contain 409 to 4290 ppm (as shown in **Figure-3**):

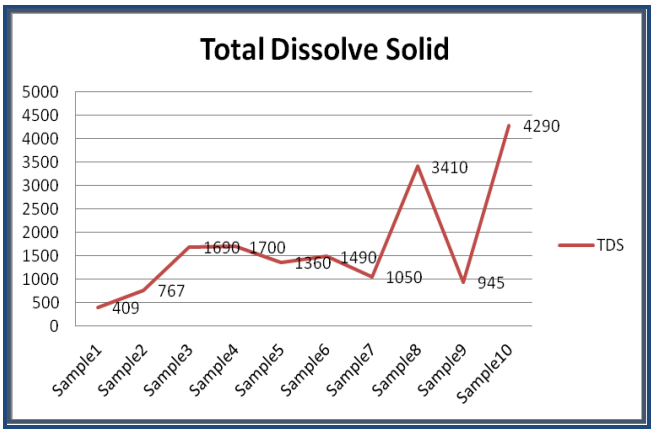
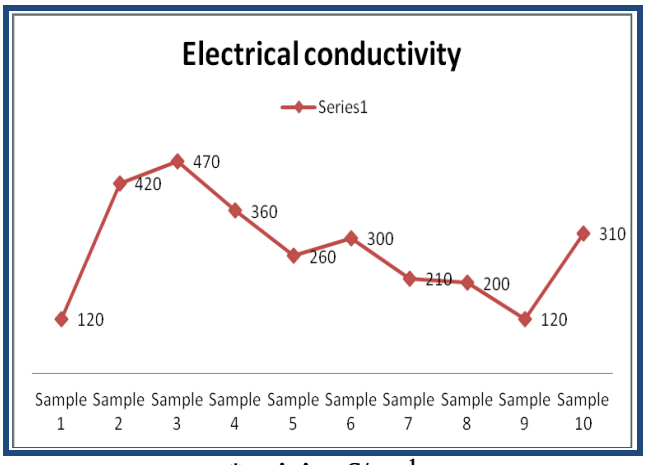


Fig -3- Showing the TDS graph.

➢ *Electrical Conductivity (EC)*

EC is determined with the help of an electrical conductivity meter. which measured the capability of water to pass electrical flow. This ability directly depends on the concentration of conductivity ions present in the water. The outcome values of electrical conductivity are given in **Table-5** and The Graphical representation is given below.



*** unit in µS/cm^{-1}**

Fig -4- Showing the EC graph.

➢ *Chlorides*

Chlorides are the inorganic compound resulting from the combination of chlorine gas with metal. Some common chlorides include sodium chloride (NaCl)and magnesium chloride ($MgCl_2$).

Water is considered to be fresh at <500 mg/L of dissolved salts. In brackish water from 500 to 30000 mg/L(3%), in saline (like seawater) from 3 to 5%, and Brine from 5 to 28%. Water is considered undrinkable at a concentration of more than 1000mg/L[27]. The results of our different samples are as follow.

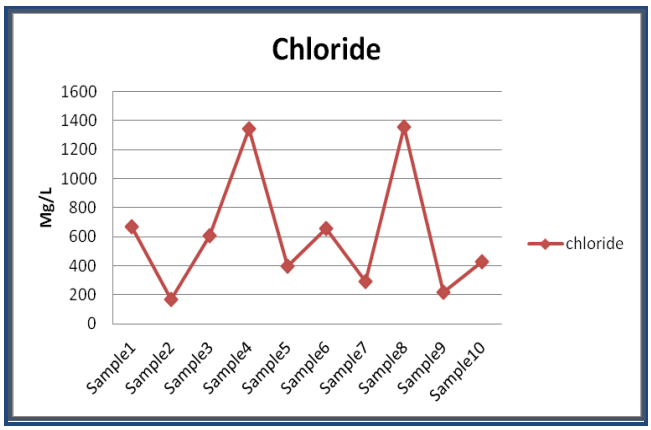


Fig -5- Showing the Chloride graph.

➢ *Chemical Characterization:*

The various chemical parameters have been used to analyze the turbidity in contaminated wastewater. The chemical parameters are hardness, alkalinity, acidity, and COD. The hardness of water talks about how much amount of dissolved calcium and magnesium are present in water.

Hard water ----------Means----------High dissolve minerals.

The hardness of industrial wastewater is given below in Figure-6.

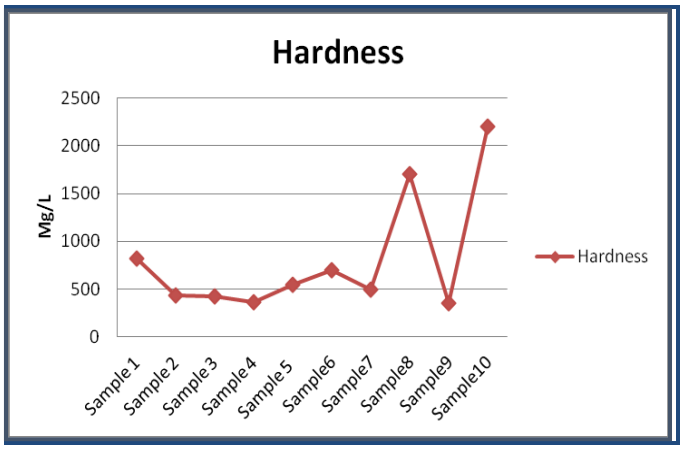


Fig 6- showing the Hardness graph.

➢ *ACIDITY*

Acidity is the measure of the capacity of water to neutralize bases. The acidity of water is its base neutralizing capacity. Water with higher capacity can neutralize a large quantity of base without a large change in pH. Acidity levels in wastewater indicate its corrosive properties a can take a leading chemical (such as chemical coagulation and flocculation) as well as a biological process.

According to Environmental Protection Agency (EPA) sampling and preventing guidelines, the outcomes of our acidity samples are as follow (Figure-7).

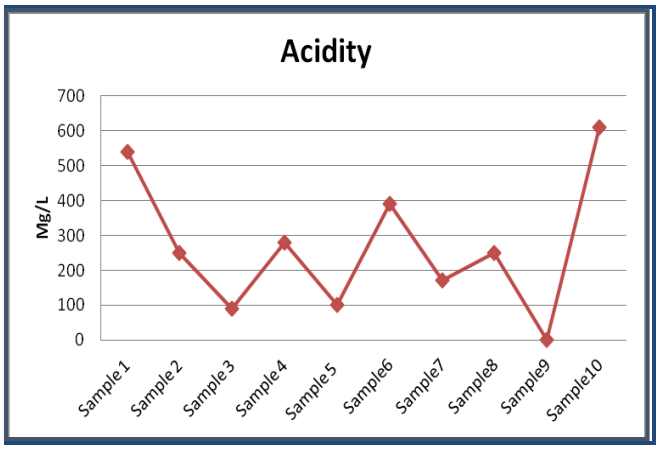


Fig 7- Showing the Acidity graph.

➢ *ALKALINITY*

It is a chemical property of water that is dependent on the presence of certain chemicals in the water such as Bicarbonate, carbonate, and hydroxide. It is defined as measuring the capacity of the water to neutralize the acid. The permissible value of alkalinity as recommended by the Indian standard is 200mg/l for $CaCO_3$. The alkalinity value of the water sample has been obtained from experimental studies as shown in (Figure -8).

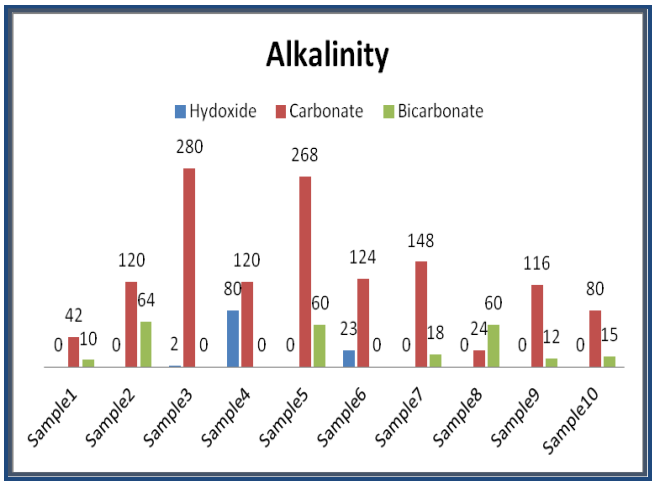


Fig-8- Showing the Alkalinity graph.

➢ *COD*

This term means the amount of oxygen required for the oxidation of oxidizable organic matter by a strong oxidizing agent. A high level of chemical oxygen demand is due to the presence of chemicals that may be organic or inorganic caused by the inflow of domestic and industrial waste that contains elevated levels of organic pollutants. The result of our different samples is given in (Figure-9).

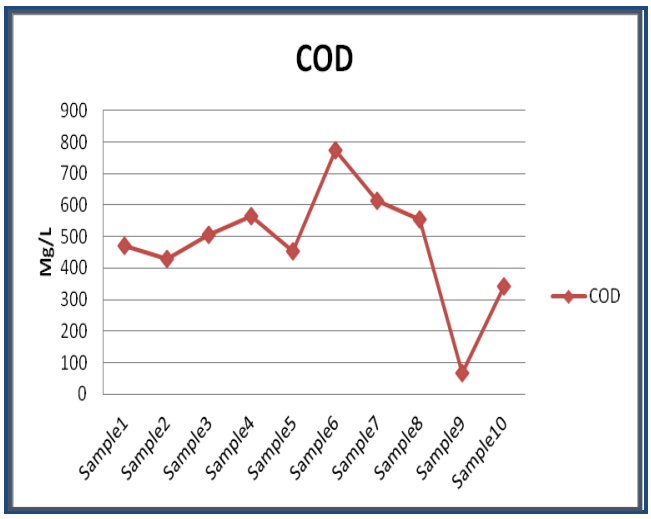


Fig-9- Showing the COD graph.

Table-7| General Standards for Discharge of Environmental Pollutants[9,26-27-28].

Parameters	USEPA	WHO	ISI	ICMR	CPCB
PH	**6.5-8.5**	**6.5-8.5**	**6.5-8.5**	**6.5-9.2**	**6.5-8.5**
Total hardness	**-**	**500**	**300**	**600**	**600**
Alkalinity	**-**	**-**	**-**	**-**	**600**
COD	**250**	**120**	**-**	**-**	**250**
TDS Chlorides	**-250**	**300200**	**-250**	**-1000**	**5001000**

* Unit in **mg/l**

➢ *Levels of Na, K& Li in wastewater samples (Flame photometry):*

The results of sodium, potassium, and lithium concentration in wastewater samples are collected from different sites. These are as given below:

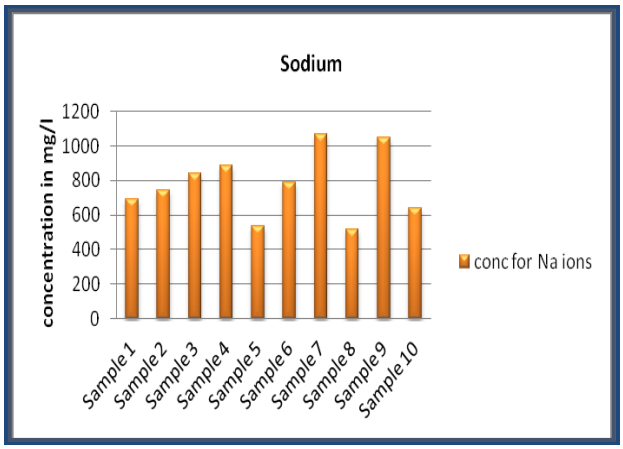


Fig-10- Showing the Sodium ion concentration graph.

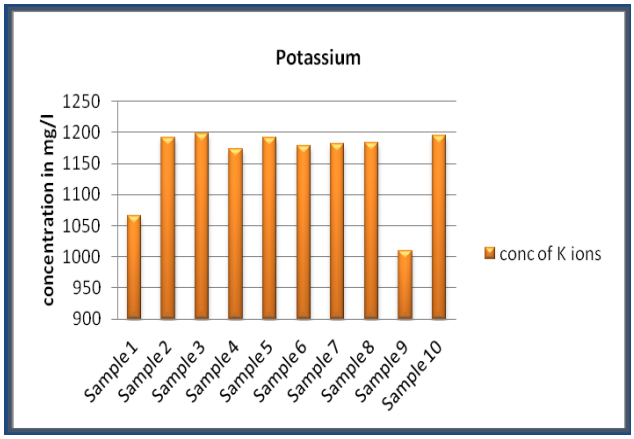


Fig-11- Showing the Potassium ion concentration graph.

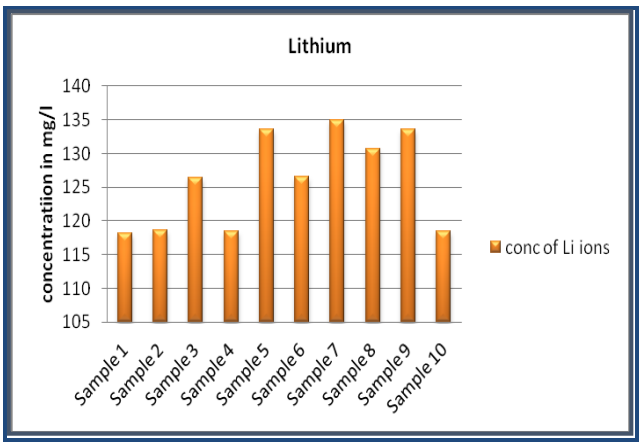


Fig-12- Showing the Lithium ion concentration graph.

➢ *Scales of Heavy metals in wastewater samples (AAS) :*

The heavy metals concentration in the wastewater samples of the Sikandra and Foundry Nagar industrial area is summarized in Table-8, the results obtained from this table revealed that the concentration of the heavy metals is found to be in the order of Cr> Cd> Mn>Cu>Pb. thus [Cr & Cd]

was identified as the most abundant in the wastewater samples. The concentration of heavy metal was higher than the permissible limit set by WHO and USEPA which could pose a huge threat to human health and the natural environment.

Table-8| The heavy metal concentration in water samples and comparison with water standard guide line[26,29].

Wastewater	Heavy Metals Mg/L.				
Sample Type	Chromium(Cr)	Cadmium(Cd)	Manganese(Mn)	Lead(Pb)	Copper(Cu)
S1	0.95	0.07	0.88	0.045	0.075
S2	0.73	0.05	0.63	0.088	0.027
S3	0.57	0.06	0.52	0.083	0.052
S4	0.22	0.08	0.48	0.072	0.031
S5	0.47	0.05	0.71	0.063	0.052
S6	0.53	0.04	0.62	0.022	0.092
S7	0.61	0.03	0.58	0.029	0.062
S8	0.001	0.002	0.004	0.0001	0.001
S9	0.001	0.002	0.003	0.001	0.001
S10	0.72	0.05	0.66	0.023	0.07
WHO	**0.10**	**0.003**	**0.50**	**0.05**	**0.01**
USEPA	**0.10**	**0.005**	**0.05**	**0.015**	**1.00**

***Graphical representation of Heavy metals (samples V/S concentration)-**

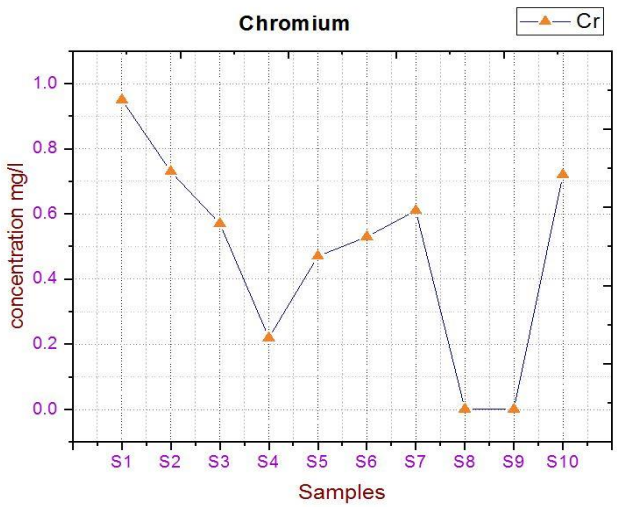


Fig 13- A plot showing Chromium concentration of water samples.

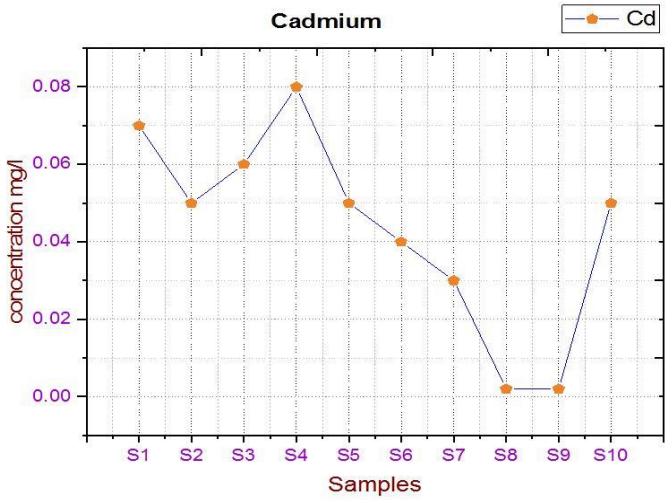


Fig 14- A plot showing Cadmium concentration of water samples.

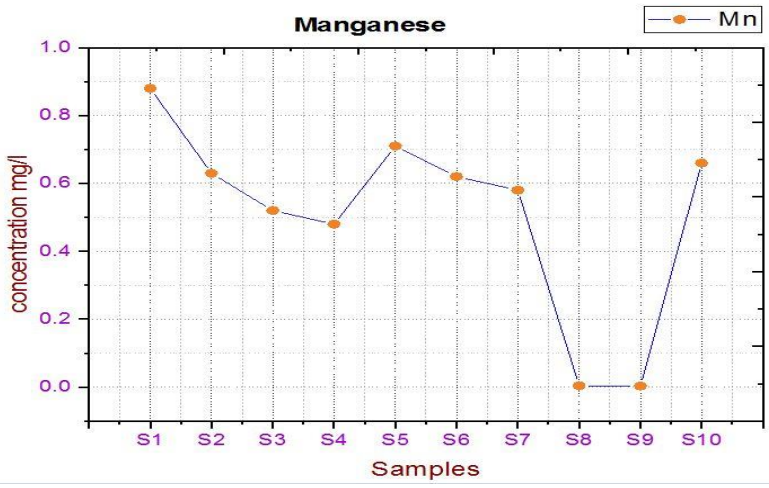


Fig 15- A plot showing Manganese concentration of water samples.

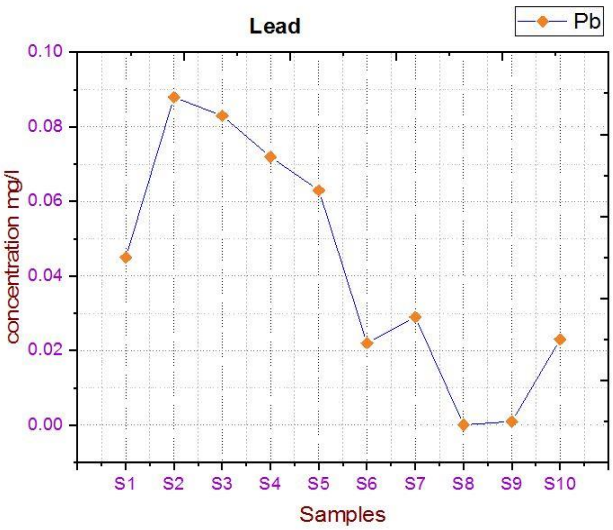


Fig 16- A plot showing Lead concentration of water samples.

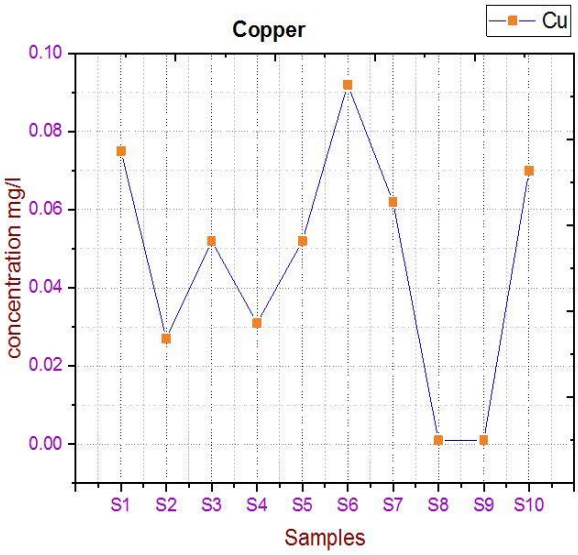


Fig 17- A plot showing the Copper concentration of water samples.

➢ *Statistical approach :*

- *Correlation matrix-*

The interrelationship studies between different Physicochemical parameter in wastewater were analyzed by Pearson product moment correlation coefficient(PPMCC). It is a bivariate distribution means if the change in one variable affects a change in the other variable.[30] The correlation coefficient 'r' was calculated by using the following formula.

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2}} \quad (1)$$

where, x and y represent two individual dissimilar parameters
n - numbers of samples

Fig 18- show Correlation coefficient strength and direction of correlation.

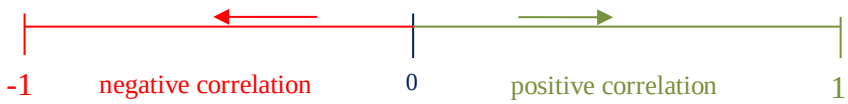


Table-9| show relation of Pearson correlation and range.

Relation	Range
Not correlated	<0.1
Weak	0.1 to 0.2
Moderate	0.2 to 0.5
strong	>0.5

According to Table 6 - The highly positively correlated values was found between TDS and Hardness(0.883), Acidity and Hardness(0.576) whereas strong negative correlated values was found between pH and acidity (-0.723), Temp and Acidity (-0.670) and moderate negative values found between chloride and Alkalinity(-0.334) . It was noted that all the parameters are partially positive and partially negative with each others.

IV. CONCLUSION

- It is evident from the above investigation that Agra city is becoming polluted because effluents are descending their way to the Yamuna River and canals.
- Most samples are showing pH value within the range but Four samples (S5, S6, S7, S10) have great corrosion characteristics due to their low pH.

- The TDS and hardness of wastewater samples in this area are quite high.
- According to the table, the value of COD indicates that the levels of contamination are increasing.
- The concentration of sodium-potassium ions in most of the samples was found to be exorbitant.
- According to WHO the chlorides value is outclassed in all the samples, but these values are within the permissible limits of CPCB (1000) mg/l except (S1, S2).
- The excess level of heavy metals might cause several short-term and long-term health issues to the Human being overall concentration of Heavy metals in the wastewater samples is following decreasing order. Cr> Cd> Mn>Cu>Pb
- If the proper step cannot be taken, the contamination in the water body will be increased day by day. That is why it is high time to take proper precautions and strong monitoring so that the environment can be sustained in its original state.

V. SUGGESTION

- Water pollution is a key issue in the present century. Water resources are finite but the exigency of water increases day by day so we all Bhartiya need to take a step for the cleanliness of the water.
- To prevent water contamination and toxicities of metals different eco-friendly methods can be applied. These methods are divided into three categories.

➢ *Physical Treatment*

1. **Isolation**--- These technologies attempt to prevent the transport of contaminated by containing them within a designated area.
2. **Capping**--- This system is used to provide an impermeable barrier to surface water infiltration to contaminated soil for prevention of the further release of contaminants to the surrounding surface or groundwater .and the second object of capping includes controlling gas and odor emission.
3. **Subsurface barrier**

➢ *Chemical Treatment*

1. **Precipitation**-- It is the most general method for eliminating the dissolved metals from contaminated water containing toxic metals. to alter the dissolve metals in solid particle form, a precipitation reagent is used. A chemical reaction triggered by the reagent, causes the dissolved metals to form a solid particle. after this, these particles are filtered and removed.

2. **Ion Exchange**-- Ion exchange is a water treatment process generally used for water softening, demineralization, dealkalization, and decontamination of wastewater. in this process ions of a particular species in solution are replaced by other ions with a similar charge. The exchange process occurs between a resin or zeolite and a liquid. Synthetic organic ion exchange resins are very utilitarian for eviction of industrial waste metals[31].

➢ *Biological Treatment*

This is a more advanced and effective treatment. Biological treatments technologies are available for remediation of metal-contaminated sites.

These technologies are commonly used for the remediation of organic and inorganic metals.

This process is done through various types of mechanisms, including adsorption, oxidation, reduction reaction, and methylation.

1. Methylation involves attaching methyl group to inorganic forms of metal ions to form organ metallic compounds. OMCs are more volatile than inorganic metals. This process can be used to remove metals through volatilization

2. Bio Adsorbent ---

(a). **Rice Husk**- It consists of cellulose, lignin, hemicellulose, and mineral ash. [32]

It is insoluble in water and possesses a granular structure and appropriate mechanical strength. [33]

Rice husk has been modified by different methods for the removal of chromium metals from the wastewater which are given in **Table-9**.

(b). **Wheat bran** -[35] It is economically viable, biodegradable and consists of various nutrients like fiber protein, etc. he has used tartaric acid for modification of wheat bran and reported 90 % removal of Cr(IV) at pH=2.which are given in Table 9.

Table-9| Chromium eviction using modified rice husk & wheat bran as an adsorbent.

Adsorbent	pH	Metal concentration(mg/l)	Model	Removal percent	Reference
Modified rice husk	6.8	190,850	Freundlich	95%	*Agrafioti et al, (2014)*
Ozone treated rice husk	2	50,100	Freundlich	86%	*Sugashini & Begum (2015)[34]*
Wheat bran modified using tartaric acid	2.2	52	Freundlich	90%	*Kaya et al (2014)*

3. Bacterial Remediation capacity of Heavy Metal:

(a) Many Bacteria are used to reduce the concentration of heavy metals because of their ubiquity, size, ability to grow in a controlled manner, and suppleness to the environmental condition[36].

(b) After experiment studying it was found that mercury resistance bacteria such as Alcaligenes faecalis, Pseudomonas aeruginosa and *Brevibacterium iodinium* for the removal of cadmium and lead [37].

(c) Bacillus cereus has an excellent capacity for removal of chromate concentration[38].

4. Microbial Genetic Engineering:

(a) Advancement in genetic engineering, microbes are designed with desirable characteristics such as the ability to tolerate metal stress, over expression of metal-chelating proteins and peptides, and ability of metal accumulation.

(b) Chlamydomonas reinhardtii generated a significant increase in tolerance to Cd toxicity and its accumulation [39].

(c) Escherichia Coli(ELPI53AR) to target As (III) and saccharomyces crevisiae(CP2HP3) to target Cu^{2+} and Zn^{2+} significantly [40].

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IMAGES DURING EXPERIMENTAL WORKING