IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁜ Vol. 9, Issue 5, May 2022

DOI: 10.17148/IARJSET.2022.9507

Investigation of Metal detection by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES)

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Abstract: Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) methods are used for the detection of metals in the study area of Satpur and Ambad MIDC of Nasik. Cu, Zn, Cd, Pb, Hg, As, Ni, Fe, Ni, Cu and Mn are studies at ten sampling sites. It was found that heavy metals like Hg, As, Cr, Ni, Cd, Pb, Zn and Cu ions are serious environmental pollutants frequently encountered in industrial waste water from textile dyeing and printing, pesticide, chemicals, pulp and paper, sugar industries etc.

Key words: Metals, ICP-AES, Pollution, Hg, As, Cr, Ni, Cd, Pb, Zn etc

INTRODUCTION

Water pollution due to hazardous heavy metals has been a major global concern for environmentalist because some moities are non-degradable. It is well perceived that there is a permissible limit for each metal, above which they are generally toxic and some are even hazardous. Contamination of environment with heavy metals from industrial waste water is a major problem (Baruch et al., 2000). Due to their accumulation through food chain and persistence in nature, it is necessary to remove heavy metals from the wastewater.

The industrial wastewater causes soil, river and groundwater pollution besides causing a number of adverse effect on agriculture produce, animal and health of people living in neighboring area, since it contains waste chemicals and toxic heavy metals (Jarup et al., 2003). The effluent from industry contains variety of organic and toxic heavy metals depending upon the nature of raw materials used and manufacturing processes adopted.

The heavy metals present in industrial effluents interact with organic and inorganic species and forms complexes. Insoluble complexes are deposited on the surface of the soil but the soluble complexes formed so far have a tendency to percolate through the soil strata (Shrivastava et al., 1999, Modia et al., 2003) which affect the quality of groundwater and soil gets deteriorated influencing the plant growth in the area (Mathur et al., 1998). A considerable amount of work has been carried out on these aspects (Kakatia et al., 1990 and Mathur et al., 1998).

Heavy metals are those whose densities greater than 59 cm^3 and light metals are those whose densities less than 5 cm^3. Many trace metals are essential at low concentrations for normal life but beyond the concentration limit they have high toxic potential to man. Once made available to the environment, metals are not usually removed rapidly, nor are they readily detoxified by metabolic activity.

As a result they accumulate. Metals enter in human body by different pathways and causes harmful effects (Nisha et al., 1994). Different metals create different problems in the human bodies. Higher concentration of metal ions in drinking water causes physiological disorders; many of them are quite serious. These metals have cumulative effects. The adsorption of metals in body system is high and excretion is slow. There are numerous reports on the harmful effects of heavy metals and have been reviewed by several authors (Mishra et al., 1992).

Many of the scientists including reported about the concentration of hazrdous metals and organic matter in the soil. They have concluded that metals and organic matter in industrial waste water percolate through the soil strata and affect the groundwater of the adjoining area (Trivedy et al., 1992, Palaniappan et al., 2003, Reddy et al., 2005). Therefore it has been considered worthwhile to investigate the strength of metal ions in industrial waste water to study their effects on nearby soil and ground water samples by ICP-AES techniques. This paper based on detection of metals from wastewater and industrial area water of Satpur MIDC, Nasik and Ambad MIDC, Nasik. Ten different metals have been studied with the help of ICP-AES from 10 different sites.

MATERIAL AND METHOD

Out of the large number of metal ions detected qualitatively in the industrial waste water, our investigations were focused for a variety of reasons only on a few of these viz; Cu, Zn, Cd, Pb, Hg, As, Ni, Fe, and Cr were detected by ICP-AES.

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RESULT AND DISCUSSION

In the present investigation, the selected industrial waste water were collected from different sites from Nashik region and analysed for the concentration of Cu, Zn, Cd, Pb, Hg, As, Ni, Fe Ni, Co and Mn by ICP-AES technique. The results thus obtained are being described and discussed as follows

1] Copper (Cu): During the course of present investigation copper was found in all industrial waste water samples. The concentration of copper in waste water samples (Table 1) at different sites was found to be in the range 0.05-1.33 µg/ ml. Copper has tendency to form complexes with suitable organic species present in industrial waste water. Several metals are precipitated by carboxylic acid.

The copper is used in electrical industry because of its high conductivity. It is also used for water pipes because of its inertness. Over 1000 different alloys of copper exist. Bordeaux mixture is basic and is made from $CuS0_4$ and $Cu(OH)_2$. It is an important fungicide. This faces supports the high cone, of copper in industrial waste water. Due to the ponding and flowing of such copper containing effluents in the region affects the soil and groundwater quality of the area due to percolation. The concentration of copper in ground water samples is in the range of 0.77µg/ml at two selected sites. The surrounding population uses this water for the various purposes like drinking, bathing and irrigation. Copper is the essential to life and adult humans contain about 100mg. Through small amount of Cu is essential, higher amounts are toxic about 4-5 mg. of Cu are required daily in the diet, and deficiency in animals results in inability to use iron stored in liver.

2] Zinc (Zn): Zinc is used in large amount for coating iron to prevent it from rusting. A thin coating of zinc may be applied electrolytically (galvanizing). Zinc has an important biological role in the enzyme systems of animals and plants. Humans contain about 2 gm. of Zinc.

In most natural wastes Zn is found in traces (less than 1 mg/L i.e. well within the safe limit). Concentrations above 5 mg/L cause a disagreeable taste. In drinking water the level of Zinc usually ranges from 0.005 to 1 ppm or mg/ L, but in certain regions it may exceed upto 7.0 mg/L. The ISI and ECC have set a maximum permissible limit 5 mg/L for Zn in drinking water. In human the oral administration of high Zn usually does not cause any side effects but mild gastrointestinal complaints can occur. In the present investigation the concentration of Zn in industrial waste water samples at different sites was found to be in the range of 0.7-13.0 .ug/1.

This data shows that, the concentration of Zn in all the waste water samples (except 2 samples) is well below the safe limit recommended by ISI and ECC.

3] Cadmium (Cd): Cd is used for protecting steel from corrosion. Cd adsorbs neutrons very well, and is used to make control rods for nuclear reactors. Cd is also used for alkaline Ni/Cd storage batteries used both in diesel locomotives, and also as the ‘nicad’ rechargeable ‘dry batteries’ used in radio and electrical appliances cds is an important but expensive yellow pigment. This is used in paint. Cd is extremely toxic. The manufacture of Ni/ Cd batteries has caused problems in Sweden and Japan. There is also concern at the amount of Cd in cigarette smoke. If Cd is ingested it accumulates in the kidneys. It causes malfunction of kidneys and also replaces zinc in some enzymes, thus preventing them from working.

4] Lead (Pb) : According to rough estimation about 2,10,000 tons of lead are released annually into the environment (22) in variety of ways like in fumes dusts, from industrial effluents, Pb pipes, paints pigments, varnishes, printing inks etc. Lead arsenate is used as a pesticide in agriculture Inorganic leads acts as an agent to cause an variety of effects on human health including liver and kidney damage, gastrointestinal damage, mental health effects in children and abnormalities in fertility and pregnancy. Adults with less than 80 µg/100 gm of blood and urine are considered to be within normal limits. Pb affects at least five stages in the formation of heam part of hemoglobin, but in enzymes most affected are S amino laevulinic dehydratase and ferrochetalase. This inhibition of haem synthesis results in anemia. The active sites of the enzymes that depends on the SH groups are inhibited by Pb. In this case Pb reacts with SH group on enzyme molecule to form mercaptide leading to inactivation of the enzymes. In the present study the concentration of Pb in industrial wastewater found to be in the range of 0.01-2.62µ g/1.

5] Arsenic (As): Arsenic is a toxic, non-essential element and widely occurs in nature. It is used in alloys, pesticides, wood preservatives and some medicinal preparations. It was formerly used in paints pigments but this use discontinued when it was found that, under damp conditions, mould converted the arsenic to the highly toxic gases like arsine (As_2H_2) and trimethyl arsine $As(CH_3)_3$ It is also present in many sulphide ores of metals and is therefore emitted from metal smelters as an atmosphere pollutant. Coal also contains significant amount of arsenic and its combustion accounts for 20 % of atmosphere emission. Coal ashes are also a significant source of As which can be leached out into

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water on the soil. During the course of present investigation, the concentration of As was found to be not detected (ND) in all industrial waste water samples.

6] Mercury (Hg): The largest use of mercury is in electronic cells for the production of NaOH and CI_2. The electrical industry uses Hg in mercury vapour street lights, switches and rectifiers. Hg has been used in the extraction of Phenyl Mercury (II) acetate and other organo mercury compounds have fungicidal and germicidal properties they are sometimes used in agriculture for treating seeds. Hg has been used in antifouling paints for ships.
All Hg compounds are toxic, but the organo compounds are extremely dangerous and have lasting ecological effects. Mercury vapour is toxic and if inhaled can cause giddiness, tremors, lung damage and brain damage. Inorganic compounds such as $HgCl_2$, Hg_2 CI_2 and HgO are also poisonous if eatten. Mercury is cumulative poison. Because they have no biological function, there is no mechanism for excreting them from the body.
The Hg came from loses from factory uses Hg (II) salts to catalyse the production of acetaldehyde from acetylene. The HgCl was converted to organo mercury compound MeHg by anaerobic bacteria in the mud on sea bed. This is concentrated in food chain first it is taken up by plankton, which is eaten by the fish, and other sea food, which in turn is eaten by man. During the course of present investigation (Table - 1) the concentration of mercury in industrial waste water samples at two sites was found in the range (0.16 - 0.17 µg/ml). While Hg was not detected (ND) in other waste water samples.

7] Iron (Fe): Iron is used in larger quantities than any other metal, and steel making is of immense importance throughout the world. Iron is also the most important transmission element in plants and animals. Its biological importance is an electron carrier in plants and animals. (Cytochromes and ferredoxins), as haemoglobin, the oxygen carrier in the blood of mammals, as myoglobin for oxygen storage, for iron Scavenging and storage (ferretin and transferrin) and in nitrogenase (the enzyme in nitrogen fixing bacteria). Iron forms several unusual complexes including ferrocene. During the course of present investigation the concentration of iron was detected in all waste water (Table-1) in the range of 1.35-16.2 µg/ml.

Table 1: Concentration of metals by ICP-AES

Sr. No.	Site of samples collection	Metals ppm or mg/1									
		Cu	Zn	Cd	Pb	As	Hg	Fe	Ni	Co	Mn
1	Gaurav Nitrate Pvt. Ltd. **¥-42,** MIDC, Ambad.	1.33	2.47	0.01	2.62	ND	0.16	12.0	1.04	0.96	4.0
2	Kulram Chemicals W-32,MIDC, Ambad.	1.42	2.33	0.02	1.47	ND	ND	13.0	1.23	0.92	3.92
3	Delta Polyster Ltd. F-6, MIDC, Ambad.	1.26	2.61	0.01	2.24	ND	0.17	12.0	1.98	0.81	4.0
4	Glaxo Industries, MIDC, Ambad.	1.21	3.0	ND	02.0	ND	ND	12.0	1.23	0.76	3.22
5	Kunal Industries J-7, MIDC, Ambad.	1.21	3.23	ND	2.1	ND	ND	3.7	1.46	0.88	2.26
6	Alpha Mech. F-101,Satpur,MIDC.	0.77	12.6	ND	1.0	ND	ND	16.2	0.92	ND	ND
7	Apurva Chemicals 45W-32,Satpur,MIDC.	0.77	13.0	ND	ND	ND	ND	ND	16.7	0.98	ND
8	Delta Industries 121, MIDC, Satpur.	0.84	12.8	0.01	1.34	ND	ND	17.0	0.93	ND	ND
9	Bharat Inorganics Chemical, MIDC, Satpur	0.05	0.72	ND	0.01	ND	ND	1.37	0.92	0.01	1.23
10	Nasik Chemicals Pvt. Ltd H-16, Satpur MIDC.	0.66	0.74	ND	0.01	ND	ND	1.35	0.77	0.01	1.04

8] Nickel (Ni): Most of the Ni produced is used to ferrous alloys. Nickel improves both the strength of steel and its resistance to chemical attack. Stainless steel may contain 12-15% Ni and steel for cutlery contains 20% Cr and 10% Ni very strong permanent magnets are made from alnico steel. Ni is used for electroplating.
Some Ni is used in Ni/Fe storage batteries, which have advantage that they can be charged at very fast rates without damaging the battery plates. Small amount of very finely divided nickel (Raney Ni) are used for many reduction process, e.g. the manufacture of hexamethylenediamine, and the reduction of anthraquinone to anthroquinol in the production of H_2O_2. It is a micronutrient for most organisms. During the course of present investigation, the Ni concentration in industrial waste water samples (Table 1) was found to be in the range of 0.77-1.98 µg/ml.

9] Cobalt (Co): Co forms important high temperature alloys with steel, and about one third of the metal produced is used for this purpose. These alloys find important uses, in gas turbine engines, and in high speed steel which is used to make cutting tools for lathes. Exceptionally hard alloys can be made which can be used instead of diamonds in rock

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drills e.g. stellite (50%Co, 27%Cr, 12% W, 5%Fe and 25%C). A third of the Co produced is used to make pigments for the ceramic glass and paint industries. Historical the oxide was used as a blue pigment in the ceramic industry. It is used to make blue glass. Now days it is mainly used to counteract the yellow colour of Fe and give a white colour. Vitamin B12 is an important Co complex. Co is a biological important in some enzymes. Glutamic mustase is involved in the metabolism of amino acids and ribonucleotide reductase in the bio-synthesis of DNA. Traces of cobalt are essential in the diet of animals. In the course of present investigation the concentration of Coblat in industrial waste water samples was found in the range of 0.01 - 0.96 μg/ ml. (Table-1).

10] Manganese (Mn): Ninety five percentage of the Mn ores mined are used in the steel industry to produce alloys. Ferromanganese is the most important, and contains 80% Mn. It is made by reducing the appropriate mixture of Fe_2O_3 and MnO with carbon in a blast furnace, or an electric arc furnace, Mn is important additive in making steel. It acts as a scavenger (removing both oxygen and sulphur and thus preventing bubbles and brittleness) and in addition it forms a very hard steel alloy. Mn(II) is important in both animal and plant enzymes. In mammals the enzyme arginase is produced in the liver. This is important because it converts nitrogenous waste products into urea in the ornithine-arginine citrulline cycle. The urea is carried by the blood to the kidneys where it is excreted in urine. Mn is an essential trace element for plant growth. It is added to fertilizers in parts of the world where there is a deficiency in the soil. It is essential in a group of enzymes called phospho transferases. In the present course of investigation the concentration of Mn in some industrial waste water samples was found in the range 1.04 - 4.0 μg/ ml. (Table 1).

CONCLUSION

Heavy metals like Hg, As, Cr, Ni, Cd, Pb, Zn and Cu ions are serious environmental pollutants frequently encounted in industrial wastewater from textile, dying & printing pesticide, chemicals, pulp and paper, sugar industries, mining drainage, plating, paints & ink formulation etc. Ten such hazardous heavy metals were detected form the said study ares in different sampling sites by ICP-AES.

ACKNOWLEDGMENT

Author is grateful to the **Prof C. P Sawant** from GTP College Nandurbar for his guidance and support for this research work. Author is also thankful to the Principal, Head of department of Chemistry and supporting staff of Jijamata College Nandurbar for their constant encouragement and valuable guidance throughout the course of the present research work.

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