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# Environmental Assessment due to Air Pollution near Iron Smelting Industry

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**Abstract:** The present investigation was on iron smelting industry which was located in Papankulam-Madavarvilagam Village, Tamilnadu, India and polluting the environment in the forms of fumes. The pollutant seems to affect the various plants and human beings residing at the vicinity of industry. In this industry, for a month 40-50 tones of ferric sulphate was produced using sulphuric acid, nitric acid and iron which were considered major environmental contaminant. Ditch, well, bore-well waters, plant samples like coconut tender water, *Cassia auriculata* and *Opuntia elatior* extracts were captivated from pollutant and unpollutant sites and the concentration of iron content in the captivated water samples and plant extracts were monitored and also the effect of iron on the physiology of plants was studied. On the basis of results, we concluded the exhaust from the iron smelting industry had a telling effects on the near by ecosystem. Accordingly, continuous monitoring of this polluted study site can be helped to solve this air pollution.

**Key words:** Air pollution, iron smelting industry, ferric sulphate, water and plant samples, environment

## INTRODUCTION

The disposals of industrial and agricultural waste are a problem of increasing importance throughout the world. In India and most of the developing countries untreated industrial wastes were discharged on land in the form of fumes and hazardous waste water which was used for irrigating crops. These wastes often contain high amount of trace elements which may accumulate in soils and water in excessive quantities on long term use and enter the food chain through absorption by the plants (Sikka *et al*., 2009). It is a common environmental contaminant introduced into the soil through anthropogenic activity and the danger of ferric chloride; ferric sulphate and Cd are aggravated by its almost indefinite persistence in the environment (Patel *et al*., 2005; Sikka *et al*., 2009). It enters the environment through smelting industries, attrition of automobile tires, burning of automobile oils, phosphate fertilizers and from sewage wastes which are disposed on land (Liphadzi *et al*., 2003). Heavy metals are given special attention throughout the world due to their toxic effects even at very low concentration (Nejem *et al*., 2009; Islam *et al*., 2007). Among the

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trace metals, ferric sulphate had received the greater attention because of its easy absorption and accumulation in plants and animals to levels toxic for their health.

Biomonitoring of organic chemicals such as PAHs, PCBs, TCCDs, ferric chloride and ferric sulphate using plants had been used frequently within the last 20 years in order to identify and qualify environmental pollution levels and sources. Many of these studies claim to be accurate with respect to the evaluation of acute toxic risks created by those xenobiotics. Also, the extrapolation from concentrations measured in water and plants to ambient concentrations were sometimes believed to be a possible objective. Some researchers were concluding biomonitoring as a cheap and useful sampling method. Till now neither representativeness nor comparability are achieved-the use of a wide variety of waters (ditch, well and bore-well water) monitor-plants (coconut tender water, *Cassia auriculata* and *Opuntia elatior*) makes it possible to draw general conclusions about how to fill the gap between (the place of) releases of a pollutant, its transformation, its accepting at/in a water, monitor-plant and finally its detection by the environmental analyst. Moreover, the pollutant's reactivity in the biological system, its possible detoxification and performance in the food-chain were not well understood. In regard to the physical background of the conditions being reflected by biomonitoring kinetic modelling allows the identification and quantification of variables governing the partitioning between air and vegetation (Islam *et al*., 2007).

Compartment approaches were available to describe the partitioning-processes between different environmental phases so that bioconcentration could be predicted for a variety of organic chemicals (Trapp *et al*., 1990; Tolls and McLachlan, 1994). Input data to these models have been used for substances with a wide range of physico-chemical properties but it has been shown that modelling too often fails to explain bioaccumulation under environmental conditions. Still those studies were able to prove the principal uptake mechanisms being determined by chemicals properties and plant-physiology (internal). Only a few of the publications on biomonitoring of organic air pollutants have so far taken into account both water and plant-physiology internal factors influencing the composition and concentration of chemicals identified in biological matrices. Although, it has been recognized that accumulation of organic chemicals was mainly governed by the gasphase (Simonich and Hites, 1994) the development of ambient temperatures within a certain period of time was not always monitored. Even the time a plant has been exposed to possible atmospheric pollution was not explicately related to the immissions measured.

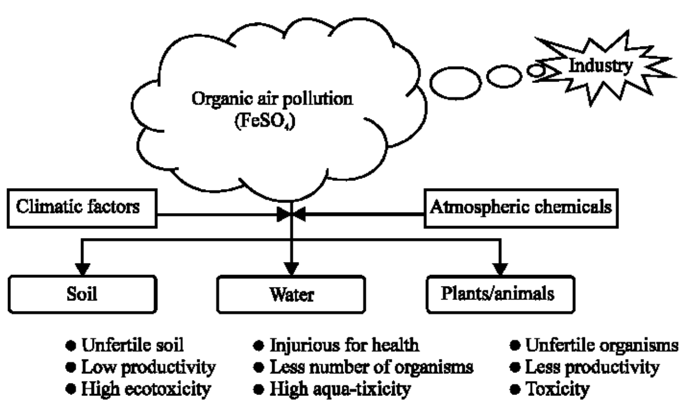


Fig. 1: Factors influencing the accumulation of organic air pollutants into soil, water and plants

A comparison of concentrations of xenobiotics measured in plants from different bigger geographical areas (Calamari *et al*., 1994; Kylin *et al*., 1994) seems to lead to wrong conclusions because there was no evidence of uniform mesoscale pollution regions and the prerequisite of uniform climatic conditions is not met either. After all concentrations of xenobiotics in a biomonitor-plants and waters were the product of surrounding pollution levels as well as the physical conditions influencing the accumulation process. To show and to evaluate this in regard to the use of waters (ditch, well and bore-well) and plants (Coconut tender water, *Cassia auriculata* and *Opuntia elatior*) as biomonitors were the aims of this study. The dependency of accumulation of organic air pollutants into soil, water and plant on different governing factors are shown in Fig. 1.

## MATERIALS AND METHODS

### Study and Samples Collected Area

Water samples namely ditch, well and bore-well waters and plant samples like coconut tender water, *Cassia auriculata* and *Opuntia elatior* were collected from polluted and unpolluted sites in colder climatic condition. The polluted area of the present investigation was situated vicinity to iron smelting industry on the Pottalpudhur-Tirunelveli roadway particularly in between Papankulam-Madavarvilagam village, Tamil Nadu, India and the investigation was performed during the period of November, 2008 to February, 2009.

In this industry, $FeSO_4$ was produced using suphuric acid, nitric acid and iron. The production rate for a month was 40-50 tones. The raw materials like iron were collected from Nagercoil factory wastes. For melting iron, coal and chlorine gas were used without temperature control system. It was a major cause for air pollution from the industry. Early days, in this industry ferric chloride was prepared for that iron was heated at ~>1800°C. By that, the fumes like red oxide gas was come out from the industry and affected the environment particularly the plant and the nature earth in the form of brown deposits. Ferric chloride is a hazardous substance, which was reported by CPPC (2000). The production of ferric chloride was stopped due to the heavy toxicity.

### Heavy Metal (Iron) Analysis in Water and Plant Samples

The iron content of normal water and water from polluted sites, coconut tender water and extracts from *Cassia auriculata* and *Opuntia elatior* were analyzed by using Atomic Adsorption Spectrophotometer (AAS) following the method mentioned in APHA (1985). Plant material was extracted, homogenized, filtered and measured against blanks using AAS working with different wavelengths for different pigments. The percentage of amount of iron content (mg $L^{-1}$) in the control and affected vegetation was calculated by using the following formula,

$$\text{The percentage calculation of iron sample} = \frac{\text{Sample-Control}}{\text{Control}} \times 100$$

In this percentage calculation of amount of iron in the samples were done by using above the formula, here sample was indicated the amount of iron concentration in selected vegetation samples, control was indicated the amount of iron in samples from unpolluted sites.

### Estimation of Chlorophyll

In addition, the total chlorophyll and chlorophyll a and b were analyzed in the normal and affected *Opuntia elatior* plant as per the procedure mentioned in Manual of Biochemistry (Jayaraman, 1985).

$$\text{Percentage calculation of loss of chlorophyll in affected sample} = \frac{\text{Sample}}{\text{Control}} \times 100$$

The percentage of loss of chlorophyll in the samples were calculated by using above mentioned formula, here sample was indicated the amount of chlorophyll content in selected vegetation samples, control was indicated the amount of chlorophyll in samples from unpolluted sites.

## RESULTS

In this present investigation, concentration of iron content in water samples collected from polluted and unpolluted area were shown in Fig. 2 and coconut tender water, *Cassia auriculata* and *Opuntia elatior* extracts were shown in Table 1. Moreover, how the pollutants impair the photosynthetic activity of plant by estimating chlorophyll content was shown in Table 2. The concentration of iron content in ditch water was found to be 0.647 mg $L^{-1}$. The concentration of iron in the water samples which were obtained from well and bore-well of polluted area was not affected (Fig. 2). The accumulation of metal iron was more in *Opuntia elatior* (1.647 mg $L^{-1}$) and then in coconut tender water (0.429 mg $L^{-1}$) and *Cassia auriculata* (0.421 mg $L^{-1}$) (Table 1).

In this study, the impact of iron on the physiology of plants was also estimated in terms of their chlorophyll content. The total chlorophyll and chlorophyll a and b were much

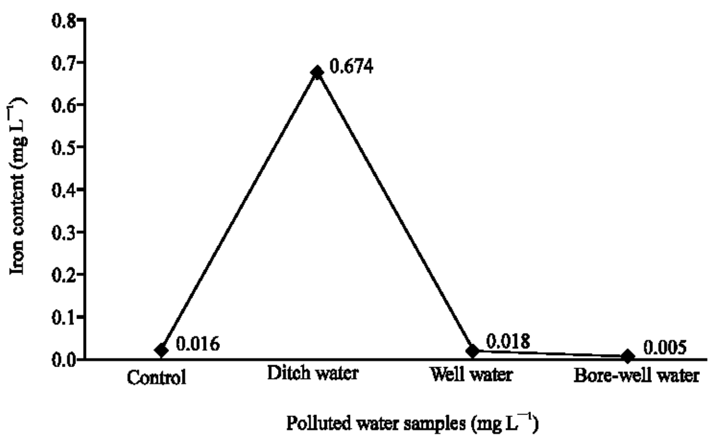


Fig. 2: The amount of iron content in the control and polluted water samples (mg $L^{-1}$)

Table 1: The amount of iron content in the control and affected vegetation (mg $L^{-1}$)

| Type of content analyzed | Control (mg $L^{-1}$) | Affected sample (mg $L^{-1}$) | Amount of iron in affected sample (%) |
|---|---|---|---|
| Coconut tender water | 0.334 | 0.429 | 28.44 |
| *Cassia auriculata* | 0.357 | 0.421 | 17.92 |
| *Opuntia elatior* | 0.155 | 1.647 | 962.50 |

Table 2: The effect of air pollution in chlorophyll content (g $L^{-1}$) of *Opuntia elatior*

| Type of content analyzed | Control (g $L^{-1}$) | Affected sample (g $L^{-1}$) | Loss of chlorophyll in affected sample (%) |
|---|---|---|---|
| Total chlorophyll | 0.38 | 0.12 | 31.57 |
| Chlorophyll a | 0.02 | 0.01 | 50.00 |
| Chlorophyll b | 0.20 | 0.02 | 10.00 |

affected than the control samples due to the effects of iron. The increased accumulation of iron content in *Opuntia elatior* (1.647 mg $L^{-1}$) directly affects the total chlorophyll content and the percentage loss in *Opuntia elatior* was found to be 31.57 (Table 2).

## DISCUSSION

Most of the organic pollutants enter the environment through smelting industries, attrition of automobile tires, burning of automobile oils, phosphate fertilizers and sewage wastes which are disposed on land (Liphadzi *et al*., 2003). Karabash, in the South Ural Mountains of Russia, was described in 1992 by the United Nations Environment Programme as one of the most polluted towns in the world. This is due to the presence of a Cu smelter and a number of abandoned mine workings and waste dumps and tailings within and around the town. The copper smelter is not large by international standards but currently has no controls on gaseous or particulate emissions (Voskresensky, 2002). Karabash and its surrounding areas are therefore affected by high levels of $SO_2$ and metal-rich airborne particulates, effluents from the smelter and leachates and dusts from waste dumps and abandoned mines (Udachin *et al*., 2003). This had led to a variety of health problems in the local population, particularly in children from exposure to high levels of lead (REFIA, 1997; Revich, 2000).

Nejem *et al*. (2009) reported the concentration of transfer factor of some heavy metals including copper (Cu), Zinc (Zn), silver (Ag), lead (Pb), mercury (Hg) and cadmium (Cd) in some fruit and leaves of plants grown the polluted soil were determined using atomic absorption spectroscopy. They showed a significant pollution of plants with some of the studied metals which exceeded in some cases the allowed vales approved by WHO and FAO. The concentration of Cu, Zn, Ag, Pb and Hg were in the range: 0-14.5, 5.9-115.4, 0-1.8, 0-68.0 and 7.3-29.6 μg $g^{-1}$, respectively. Its shows the transfer factor was varied amongst the plant and also amongst the species of the metals. A better understanding of the physical and chemical properties of smelter particulate emissions is important for optimizing these measures and for understanding the effects of past and present emissions on human and environmental health.

Heavy metal contamination of the environment which has been recognized as a serious pollution problem is capable of exerting considerable biological effects even at low levels because of their pervasiveness, persistence and non biodegradable nature (Singh and Chandel, 2006). In this present investigation, concentration of iron content in water samples collected from polluted and unpolluted area were shown in Fig. 2 and coconut tender water, *Cassia auriculata* and *Opuntia elatior* extracts were shown in Table 1. In addition to that how the pollutants impair the photosynthetic activity of plant was shown in Table 2. Plants could be collected at colder climatic condition due to be better biomonitor than plants losing their overall vitality in autumn (Franzaring, 1997). Singh and Chandel (2006) reported Fe concentration 0.1-0.4 mg $L^{-1}$ in wastewater samples. Figure 2 shows the concentration of iron content in ditch water was found to be 0.647 mg $L^{-1}$. The concentration observed in the present study in found to be elevated than World Health Organization (WHO) prescribed recommended limit of 0.3 mg $L^{-1}$, Industrial Toxicology Research Centre, India recommended limit of 0.3 ppm and Singh and Chandel (2006) results (0.4 mg $L^{-1}$). The concentration of iron in the water samples which were obtained from well and bore-well of polluted area was not affected (Fig. 2). It was reveals how the study area was polluted by the industrial air pollution.

In same way, the prescribed recommended iron concentration of WHO report was compared with the concentration of iron in various samples like coconut tender water and the extracts of *Cassia auriculata* and *Opuntia elatior* were collected from pollutant (study) and unpolluted sites. The results were shown, the accumulation of metal iron was more in *Opuntia elatior* (1.647 mg $L^{-1}$) and then in coconut tender water (0.429 mg $L^{-1}$) and *Cassia auriculata* (0.421 mg $L^{-1}$) of the recommended level of WHO (Table 1). Regarding the total iron concentration shown in Table 1 it could be followed that different plant species seem to have different capacities for the accumulation of organic air pollutants. Crops and vegetation are one of the principal sinks for accumulation of the trace metals and these edible portions if contaminated with levels higher than the maximum permissible limits may be detrimental to human and animal health. This is a matter of serious concern as vegetable leaves are xylem sinks and provide easy entry of these trace metals into food chain (Oliver, 1997).

The high concentration of heavy metals such as $FeSO_4$ and Cd in plants affects adversely various metabolic processes in plants such as synthesis of chlorophyll, protein, carbohydrate, free amino acids and RNA etc (Patel *et al*., 2005). In this study, the impact of iron on the physiology of plants was also estimated in terms of their chlorophyll content. The total chlorophyll and chlorophyll a and b were much affected than the control samples due to the effects of iron. Franzaring (1997) was reported the amount of chlorophyll a and chlorophyll b tend to increase from late summer to winter answering the drop in temperature and photo-active radiation and also he reported changes in pigment amounts reflect a strong seasonal change in plant-vitality and growth which can cause different accumulation characteristics in pollutant uptake. It was to be worth mentioned that the increased accumulation of iron content in *Opuntia elatior* (1.647 mg $L^{-1}$) directly affects the total chlorophyll content of the same plants at colder climatic condition. The percentage loss in *Opuntia elatior* was found to be 31.57 (Table 2). These obvious new results suggested that the exhaust from the iron smelting industry had a telling effects on the near by ecosystem. According to the aim of the present investigation, water samples, in particular ditch water was shown high concentration of iron, more amount of metal iron accumulated by *Opuntia elatior* was detected and the impact of iron on the physiology of *Opuntia elatior* was also estimated in terms of their loss of chlorophyll content. It was expose how the study area was polluted by the air pollution of iron smelting industry. Before suggesting our results, no investigation was made in this study area.

## CONCLUSION

Despite the fact that rich in plant nutrients, the contaminated waters and soils often have high concentrations of trace metals such as Cu, $FeSO_4$, Zn, Pb, Cd, Ni and Cr and their continuous application may result in build up of toxic concentrations in soils and possible transfer to plants grown on them (McBride *et al*., 1999). On the basis of results, we concluded that the study area was being polluted by air pollution which is caused by the iron smelting industry. The effect was manifold in terms of accumulation and there by reduction in chlorophyll content of plants. To reach better results in biomonitoring of organic air pollutants would necessarily need a very high degree of standardization to overcome the problems related to concentration-effects. Monitor-systems must be applied to identify the physical and chemical environment of the plant to better understand the uptake-mechanisms of the growing diffusive sampler. Accordingly, continuous monitoring of this polluted study site can be helped to solve this air pollution and also recommended some remedial measures can be taken into the account of stopping further air contamination.

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**REFERENCES**

APHA, 1985. Standard Methods for the examination of water and wastewater. 16th Edn, APHA, Washington. DC., ISBN: ISBN 0-87553-235-7.

Calamari, D., P. Tremola P.A. DiGuardo and M. Vighi, 1994. Chlorinated hydrocarbons in pine needles in Europe: Fingerprint for the past and recent use. Environ. Sci. Technol., 28: 429-434.

CPPC., 2000. Code of Practice on Pollution Control (2000 Edition) (with amendments in Feb 2001, Jun 2002 and Feb 2004). http://www.nea.gov.sg/cms/pcd/coppc_2002.pdf.

Franzaring, J., 1997. Temperature and concentration effects in biomonitoring of organic air pollutants. Environ. Monit. Assess., 46: 209-220.

Islam, E., Y. Xiao-E, H. Zhen-li and M. Qaisar, 2007. Assessing potential dietary toxicity of heavy metals in selected vegetables and food crops. J. Zhejiang Univ. Sci., 8: 1-13.

Jayaraman, J., 1985. Laboratory Manual I n Biochemistry. 1st Edn., Wiley Eastern Ltd., New Delhi, India, ISBN: 0852264283.

Kylin, H., E. Grimvall and C. Ostman, 1994. Environmental monitoring of PCBs using pine needles as passive samples. Environ. Sci. Technol., 28: 1320-1324.

Liphadzi, M.S., M.B. Kirkham, K.R. Mankin and G.M. Paulsen, 2003. EDTA-assisted heavy metal uptake by popular and sunflower grown at a long term seweage-sludge farm. Plant. Soil, 257: 171-182.

McBride, M.B., B.K. Richards, T. Steenhuis and G. Spiers, 1999. Long-term leaching of trace elements in a heavily sludge amended silty clay loam soil. Soil. Sci., 164: 613-623.

Nejem, R.M., N.M. El-Ashgar, M.M. Issa and M. Al-Slieby, 2009. Detection of some heavy metals due to sewage water diffusion into planted land. J. Environ. Sci. Technol., 2: 88-94.

Oliver, M.A., 1997. Soil and human health: A review. Eur. J. Soil Sci., 48: 573-592.

Patel, M.J., J.N. Patel and R.B. Subramanian, 2005. Effect of cadmium on growth and the activity of $H_2O_2$ scavenging enzymes in *Colocassia esculentum*. Plant Soil, 273: 183-188.

REFIA (Russian Ecological Federal Information Agency), 1997. Lead contamination of the environment in the Russian federation and its effect on human health. State Committee for Environmental Protection of the Russian Federation. White Paper, Moscow. ISBN: 5-7844-0028-2.

Revich, B., 2000. Lead in the environment and children's health in russian cities. Proceedings of the 11th Annual International Conference on Heavy Metals in the Environment, (AICHME'00), University of Michigan, School of Public Health, USA., pp: 1.

Sikka, R., V. Nayyar and S.S. Sidhu, 2009. Monitoring of Cd pollution in soils and plants irrigated with untreated sewage water in some industrialized cities of Punjab, India. Environ. Monit. Assess., 154: 53-64.

Simonich, S.L. and R.A. Hites., 1994. Vegetation-atmosphere partitioning of polycyclic aromatic hydrocarbons. Environ. Sci. Technol., 28: 939-943.

Singh, V. and C.P.S. Chandel, 2006. Analytical study of heavy metals of industrial effluents at Jaipur, Rajasthan, India. J. Environ. Sci. Eng., 48: 103-108.

Tolls, J. and M. McLachlan, 1994. Partitioning of semivolatile organic compounds between air and Lolium multiflorum (Welsh Ray Grass). Environ. Sci. Technol., 28: 159-166.

Trapp, S., M. Matthies, I. Scheunert and E.M. Topp, 1990. Modelling the bioconcentration of organic chemicals in plants. Environ. Sci. Technol., 24: 1246-1252.

Udachin, V., B.J. Williwmson, O.W. Purvis, B. Spiro and W. Dubbin *et al*., 2003. Assessment of environmental impacts of active smelter operations and abandoned mines in Karabash, Ural Mountains of Russia. Sustain. Dev., 11: 1-10.

Voskresensky, G., 2002. The most polluted city on the planet to breath easier. Eurasian Metals 3 (Ecology). http://en.eurasmet.ru/online/2002/3/ecology.php.