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Metals in Wet Precipitation

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***Abstract*— Samples of wet precipitation were collected to assess the presence of metals in the wet precipitation in peenya industrial zone, Bengaluru during 12 rain events, on 2015, south-west monsoon. Collected samples were analyzed for pH and metals. The pH ranged between 4.67 - 6.60, which depicted the acidic nature of wet precipitation with a mean pH of 5.08 and presence of metals in the wet precipitation in the following order Iron > Zinc > Manganese > Aluminum > Chromium > Copper > Nickel > Lead > Cadmium. The acidic nature of wet precipitation has resulted in the solubility of metals in particulate matter. Iron was identified to be the dominant species among all the metals.**

***Index Terms*— pH, metals, wet precipitation**

I. INTRODUCTION

Atmospheric pollutants are scavenged by precipitation through two methods. They are below cloud scavenging (washout) removal of coarse mode particles and in-cloud scavenging (rainout) removal of fine mode particles and gases [4], [5] & [12]. Emissions from the anthropogenic sources have resulted in air pollution. Cations such as calcium, magnesium etc., and anions such as sulphate, bicarbonate and nitrate etc., balance the acidic and alkaline nature of wet and bulk precipitation [9] & [14].

II. MATERIALS AND METHODS

A. Site description

The site considered for the study was Peenya industrial area, Bengaluru. A fast growing metropolis with a population of 9,621,551 (Census 2011), the garden city is the capital of the southern Indian state of Karnataka. Situated at an altitude of 921 m (3021 feet) above mean sea level. The city is situated about 450 Km from the Bay of Bengal and the Arabian Sea and about 700 Km from Indian Ocean. It is known for its salubrious climate where temperatures remain moderate throughout the year.

Peenya industrial area is the largest industrial area in south east Asia. It houses around 3000 industries and some of the Air polluting industries such as Electro plating, Boilers, Foundry, Furnace, Incinerators, Diesel Generators, Battery Manufacturing, Industrial gases, Unauthorized dumping site and burning of waste, Stone cutting and grinding etc., as per "Environmental Database for Peenya Industrial Area, Bangalore 2008". It is located near Bangalore-Tumkur highway (National Highway-4).

B. Wet precipitation sampling

Wet precipitation sampling is the collection of wet fallout from the atmosphere. Wet precipitation collector consists of a polyethylene funnel of 25-cm dia connected to 20 liter

polyethylene collector It is installed over the roof of the building as shown Fig. 1 to collect the wet- only precipitation samples in the study area. Wet precipitation is collected manually during the rain events. The wet collector is cleaned after every rain event using double distilled water.

Fig. 1 Wet precipitation collector

A clean Teflon bag was inserted on the collection apparatus when no rain events occurred. The Wet precipitation collectors shall be placed on the terrace of the building at a minimum height of 3 m above from ground.

C. Sampling and Analytical methods

The wet precipitation was collected during southwest monsoon from June to September 2015 for 12 rain events where sufficient samples were available for analysis. The samples were collected in polyethylene bottles rinsed with double distilled water and visually inspected for contaminations such as bird breach, presence of dead insects, algal growth and in such cases the contaminants were discarded. After sample collection, the wet precipitation collector were rinsed with double distilled water or replaced with a new one in case of contamination. The samples were transported to laboratory immediately after collection completely covered to avoid sunlight and analyzed immediately for pH. Subsequently, the samples were filtered through whatmann 41 filter paper. All water filtrates were preserved at 4°C in a refrigerator until for analysis. For metal analysis samples were acidified using 2% concentrated Nitric acid. The samples were analyzed for pH, Manganese, Aluminum, Iron, Zinc, Copper, Chromium, Cadmium, Lead and Nickel. The pH of

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the samples was measured using SYSTRONICS (Model SYS-361) instrument. Metals were analyzed using Inductively Coupled Plasma - Optical Emission Spectrometers (PERKIN ELMER-ICP-OES (OPTIMA 8000) and Atomic Absorption Spectroscopy (AAS - Model VARIAN SPECTRAA 240). The sample analysis data has been plotted using Box and Whisker plots. Box plot depicts the cluster of data based on their quartiles showing medians. Whiskers (line extending from the top and bottom of the box) help to understand the Maximum and Minimum value of the parameter.

III. Results and discussions

The pH of the wet precipitation ranged between 4.67 - 6.60 with a mean value of 5.08 as shown in Fig. 2. It is less than the threshold point of neutrality 5.6 [6] and depicts acidic nature of the wet precipitation.

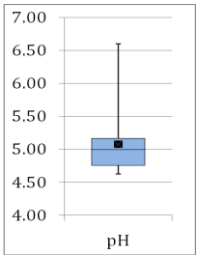

Fig. 2 pH of wet precipitation

Other studies have reported the acidic nature of the wet precipitation is due to the increasing concentrations of $SO_4^{2-}$and NO_3^- anions in the atmosphere due to the anthropogenic sources such as industrial emissions, emissions from diesel generators, traffic emissions from the neighborhood area resulting in the formation of sulfuric and nitric acid [9], [10], [12], [13] & [14] The alkaline nature of bulk precipitation has turned acidic over the last three decades as reported by Munawar Pasha, et al., 2010. The study area is one of the biggest industrial areas in Asia. It is located next to the national highway that is busy round the clock.

The wet precipitation samples were analyzed for metals. Its mean concentrations are as follows, Iron: 9.614µeq/l (0.268 mg/l), Zinc: 1.619 µeq/l (0.053 mg/l), Manganese: 0.965 µeq/l (0.027 mg/l), Aluminium: 0.81µeq/l (0.011 mg/l), Chromium: 0.751µeq/l (0.020 mg/l), Copper: 0.635 µeq/l (0.020 mg/l), Nickel: 0.258 µeq/l (0.008 mg/l), Lead: 0.041µeq/l (0.004 mg/l) and Cadmium: 0.021µeq/l (0.001 mg/l) as shown in Fig. 3.

The air quality details of the study area were collected from Karnataka State Pollution Control Board (KSPCB) to assess the PM_{10} concentration. As shown in Table I, PM_{10} concentration has crossed the prescribed standard limits of Central Pollution Control Board (CPCB) of INDIA. The particulate matter concentration is almost twice the prescribed limits. This depicts the pollution level of the study area. The pollutants present in the ambient air affects the quality of the wet precipitation [1].

TABLE 1. Annual Average Pm_{10} Concentration In Ambient Air At Different Stations In Bengaluru During 2015

SL. No.	Air sampling station	PM_{10} (µg/m3)	Source of the data
1	Peenya Gymkhana	127.30	http://kspcb.gov.in/AQI-DATA-Bangalore-CITY-Jan-Dec-2015.pdf
2	Peenya Industrial Area	134.70	
3	Yeshwanthpura	127.80	
National Ambient Air Quality Standard (NAAQS 2009) for Respirable Suspended Particulate Matter is 60.0 µg/m^3 as prescribed by Central Pollution Control Board of India.			

The various studies on the chemical composition of particulate matter reports the presence of metals in it. Extractable chromium was reported in atmospheric particulate matter [2]. Presence of lead, zinc, chromium and cadmium in wet precipitation with a concentration of 22.2, 70, 1.2 and 4 µg/L and 840, 16233, 32 and 54.8 ng/m^3 in PM_{10} were due to the heavy traffic loads and industrial activities using the enrichment factors and correlation coefficients [3]. Presence of heavy metals such as Pb^{2+}, Cd^{2+}, Zn^{2+}, Fe^{3+} and Cu^{2+} at trace levels in air borne particulate matter through electro analytical techniques viz., direct current polarography and differential pulse anodic stripping voltammetry was determined [15]. The concentrations of airborne particulate matter trace metals in the industrial district of Santa Cruz, Rio de Janeiro, Brazil, where the main source of pollution was local industrial area. The major elements including Ca, Mg, K, Na, Al, Fe, Mn and trace elements such as Zn, Cu, Cr, Co, Pb, Cd were found high in the airborne suspended particles. The Mn, Cr and Ni` concentration levels were 2.4, 4.2 and 2.1 times much higher than the standard values of the elements set by United States Environment Protection Agency (USEPA) in the air [11]. Presence of metals in the ambient suspended particulate matter of the Coimbatore city, Tamilnadu, India with concentration in the order of Zn > Fe > Cu > Pb > Cr >Ni > Cd was identified. Usage of zinc for protective coating of iron may be the reason for the metals as per the study [16]. Air quality and trace metal chemistry of different size fractions of aerosols in North-North West India by collecting three different size fractions of aerosols – free fall (FF), Suspended Particulate Matter and PM_{10} as well as surface sediments reported, Ba and Pb are added largely by fossil fuel burning; Cu, Ni and Zn are contributed by various industries [17].

These studies report the presence of metals in the airborne particulate matter from various sources and is in agreement with the present study. Rainwater quality is directly influenced by the particulate matter present in the atmosphere. The metals present in particulate matter get dissolved in the wet precipitation due to the acidic nature of pH during the rain, resulting in the presence of metals [7], [8], [14] & [3].

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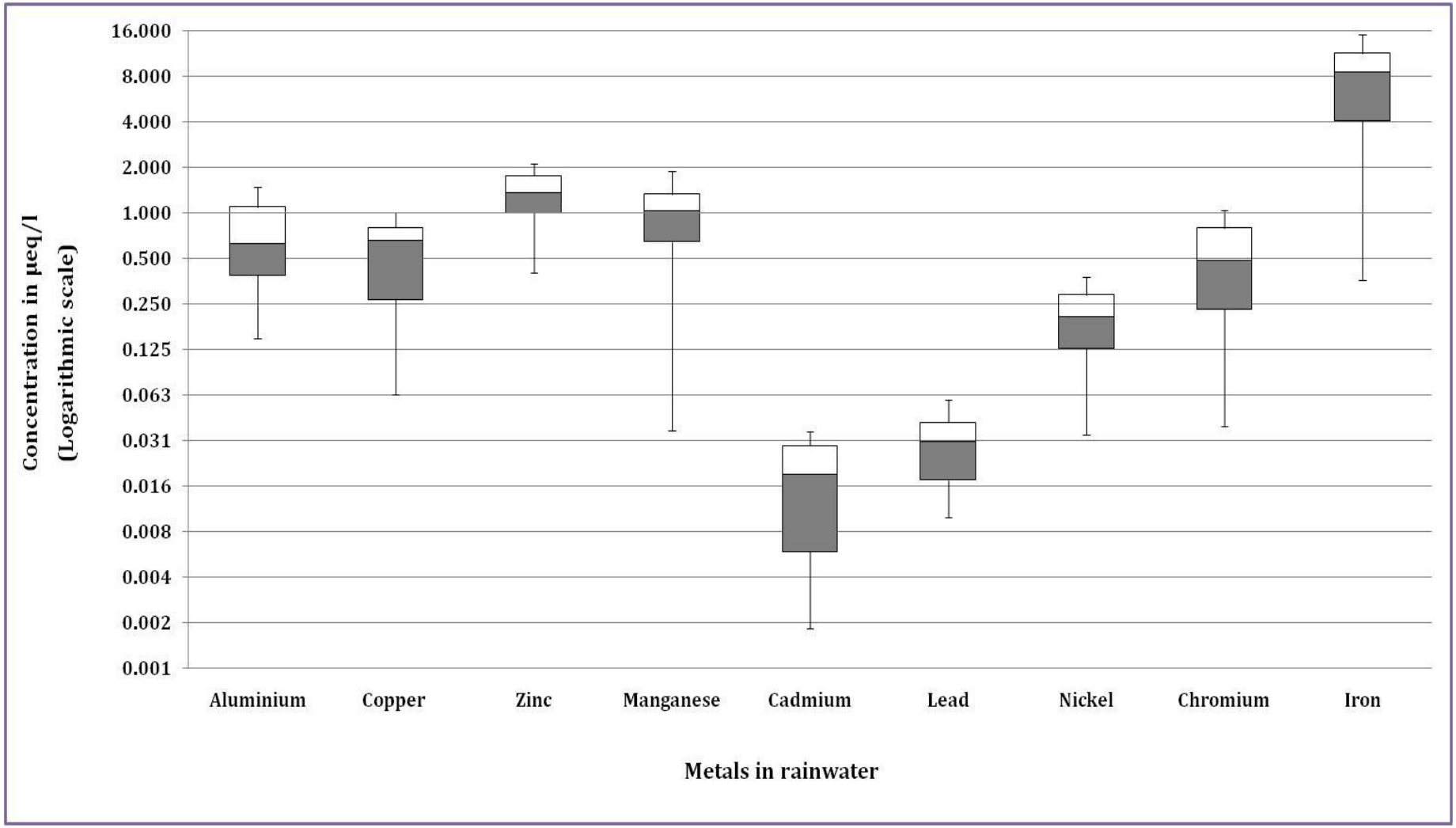

Fig. 3 Concentration of metals in wet precipitation samples collected from peenya industrial zone

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IV. CONCLUSIONS

Anthropogenic activities such as industrial emissions, traffic emissions from the nearby highway and operating diesel generators has resulted towards the emission of pollutants in the atmosphere. The particulate matter PM_{10} concentration in the study area has crossed twice the national standard limits prescribed by Central Pollution Control Board (CPCB) for ambient air quality. The presence of metals in the wet precipitation can be attributed towards the particulate matter present in the atmosphere of the study area. Iron is the dominant metal species among all the metals, which is as high as 5 times compared to the second dominant metal zinc.

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