

Blue Rock Pigeon (*Columba livia*) as Bioindicator of Heavy Metal Pollution in Industrial Ambient Air

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ABSTRACT: Even though of restraint on anthropogenic emissions, heavy metals may remain a major environmental threat at local, regional and worldwide level, due to their pervasiveness and non biodegradable nature. The aim of the present study was to biomonitor the concentration of Pb, Cd, Cr, Cu, Ni and Zn in fecal samples of pigeon collected from industrial regions of pink city, Rajasthan. Elemental composition of fecal samples was investigated by employing atomic absorption spectrophotometer (AAS) after chemical digestion with concentrated HNO₃. Pb, Cu, Ni and Zn were excreted in its lowest concentration in fecal samples from Mansarover industrial area while Cr was recorded lowest in Sitapura industrial area samples. Further, highest concentration of Pb was seen in fecal samples from Sanganer industries. However, greatest amount of Cr and Cu was present in fecal samples from Jhotwara area industrial and Vishwakarma industrial area has been observed with highest level of Ni and Zn concentration. Cd was not traceable in any of analyzed sample. This dissimilarity in levels of heavy metal pollution may be attributed to different level of environmental contaminants in studied areas due to different industrial setups. Considering the high concentrations of heavy metals in fecal matter of pigeon, we can say that there is still a danger for biota. Overall, present study suggests that pigeons may represent a good bioindicator for metal biomonitoring.

KEYWORDS: Vishwakarma industrial area, Biomonitoring, Pink city, Non Biodegradable Nature.

I. INTRODUCTION

Heavy metals are naturally occurring metallic elements that have a density that is relatively greater than water and have a high relative atomic mass. Heavy metals toxicity depends on number of parameters that includes route of exposure, dose and chemical species, as well as the gender, age, genetics, and nutritional condition of exposed organisms. As, Cd, Cr, Hg and Pb metals are considered as systemic toxicants because of their multiple organ damage effect even at their lower concentrations [1].

Expeditious industrialization and urbanization, together with development in agriculture which make extensive use of large number of chemical compounds leads to a consistent increase of heavy metal concentration in the environment; being persistent, they shows the phenomenon of bioaccumulation [2]. Jaipur is located in the eastern part of Rajasthan. Over last two decades a number of micro, small, medium and large scale industries have been established in Jaipur and nearby area. These industries are mainly divided into thirty five industrial areas such as Vishwakarma, Sudershanpura, Bais Godown, Jhotwara, Malviya, Sanganer and Sitapura industrial area on the basis of their location in Jaipur. Type of industries existing in these industrials areas are Wooden based, Cotton based, Beverages based, Tobacco based, food based, Paper based, Leather based, Rubber, Plastic/ Petro based, Mineral and Metal based industries, Engineer Units, Electrical Industry/Machinery & Appliances etc., which has a role in contaminating the environment. Industrial discharge from these industries has been found loaded with Cu, Fe, Mn, Ni and Zn while As, Cd, Cr and Pb was not detectable in industrial discharge [3]. Industrial effluents discharge make up about 62% of total source of trace metals such as nickel, cadmium, lead, manganese and chromium which are liable not only for downgrading the water condition but also responsible for the death of a number of organisms [4].

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However, each organism has its unique way to respond at different degree to alterations in environmental conditions. Birds are the finest for monitoring heavy metal contamination because of their high sensitivity to environmental contaminants than any other vertebrates [5]. Birds can acquire trace metals, internally, by consumption of contaminated water, food, industrial effluents metals, sewerage water and externally by physical contact [6]. In birds, heavy metals are correlated with aberrant incubation behaviour, lethargy and wing area asymmetry and have been shown to associate with a number of biological features such as genetic diversity (Cu, Zn, Cd and Pb), fledging success (Hg, Pb and Cd), plumage intensity (Cu, Zn, Ni and Pb), humoral immune responsiveness (Pb and Cd) and bone mineralization degree (Pb) [7].

Since biomonitoring of heavy metal pollution gives up more reliable outcomes as compared to chemical and physical analysis [8], [9] and killing of birds has been legally banned in India (Wildlife Protection Act 1972). Therefore, central aim of the present study was to use faecal matter of blue rock pigeon, as a non-invasive method, collected from different industrial areas of Jaipur and to enlighten the concentration of Cadmium (Cd), chromium (Cr) Copper (Cu), Nickel (Ni), Lead (Pb) and Zinc (Zn) in the same. Hence, determination of heavy metal levels in fecal samples is an indicator of the bioavailable fraction of the element in the environment.

II. MATERIALS AND METHODS

a) Sample collection

Faecal samples of blue rock pigeon were collected in sterile plastic bags using spatula from Jhotwara, Malviya, Mansarover, Sitapura, Vishwakarma industrial areas and Sanganer industries during month of January and February in 2017. After collection, samples were dried, marked appropriately with the source, time and date of collection. Six samples were collected from each industrial area from six different sites.

b) Preparation and Elemental analysis of samples

The dry faecal samples from different industrial regions were weighted 0.5g and 4mL of conc. HNO₃ and few drops of Perchloric acid were added. These samples are then digested in Perkin's microwave at 121°C until it was digested completely and became clear. The digested solution was left to cool up to room temperature. The final volume was made to 25mL with double distilled water and the solution was filtered using Whatman filter paper No. 40. Lead (Pb), Cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni) and zinc (Zn) were analysed in digested samples by atomic absorption spectroscopy.

The data collected was represented as mean, standard error and standard deviation. The data for different heavy metals in different industrial regions was statistically analysed by one way ANOVA at 5% confidence level.

III. RESULTS AND DISCUSSION

The results showed variation in mean metal concentrations among industrial regions and Summary statistics of heavy metals level concentrations in studied industrial regions was presented in Table-1 and Fig. 1. In the present study, Cadmium was not detectable in any faecal sample collected from six different industrial regions. The concentration of all trace metals except Cd varied significantly at 5% level of significance among the industrial regions as shown in Table-1

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Table-1 Concentration of heavy metals ($\mu\text{g g}^{-1}$) in faecal samples of pigeon is represented as mean \pm standard error and standard deviation of six samples from each industrial region. All the results were performed in dry weight.

Metal	Malviya industrial area	S.D	Sanganer industries	S.D	Sitapura industrial area	S.D	Vishwakarma Industrial area	S.D	Jhotwara industrial area	S.D	Mansarover industrial area	S.D
Pb ^a	2.92 \pm 0.50	1.13	18.95 \pm 6.08	13.60	1.88 \pm 0.03	0.74	6.50 \pm 2.59	5.79	1.195 \pm 0.39	0.88	1.01 \pm 0.20	0.45
Cr ^a	11.5 \pm 0.75	1.68	8.45 \pm 1.44	3.22	8.25 \pm 1.44	3.99	11.8 \pm 3.41	7.64	14.4 \pm 0.79	1.77	8.7 \pm 2.85	6.38
Cu ^a	2.78 \pm 1.08	2.42	17.3 \pm 5.96	13.33	24.35 \pm 0.36	0.81	11.45 \pm 0.51	1.14	30.55 \pm 6.58	14.71	1.53 \pm 0.40	0.91
Ni ^a	2.25 \pm 0.90	2.01	2.20 \pm 0.07	0.15	3.15 \pm 1.05	2.34	4.45 \pm 1.50	3.36	3.85 \pm 1.23	2.75	1.90 \pm 0.67	1.51
Zn ^a	100.1 \pm 17.02	38.07	69.95 \pm 21.47	48.01	52.55 \pm 1.45	3.25	100.8 \pm 6.33	14.16	53.45 \pm 12.90	28.84	50.25 \pm 0.32	0.72

^a Significantly differ in different areas, $P \leq 0.05$, S.D-Standard deviation.

Pb and Cd are classified among the most toxic heavy metals which have no known biochemical benefits to animals and humans [10]. Literatures reports that Pb has detrimental effects on the growth and survival of nestlings, causes haemolytic anaemia in wild Pb-poisoned birds, reproductive impairment, defects of nervous system, decrease in body weight and may result in decrease in survival and growth rates, poorer fledging success, learning and metabolism[11],[12]. Present study recorded that Pb decreases in its mean concentration among different industrial regions in the following order: Sanganer>Vishwakarma>Malviya>Sitapura>Jhotwara>Mansarover with mean values 18.95 \pm 6.08 $\mu\text{g/g}$, 6.50 \pm 2.59 $\mu\text{g/g}$, 2.92 \pm 0.50 $\mu\text{g/g}$, 1.88 \pm 0.033 $\mu\text{g/g}$, 1.195 \pm 0.39 $\mu\text{g/g}$ and 1.01 \pm 0.20 $\mu\text{g/g}$ respectively. Further, ANOVA analysis of present study represented that Pb concentration in the excreta samples were significant at $p < 0.05$. These variations in heavy metals levels may be attributed to the different anthropogenic activities among industrial regions which could have been responsible for the significance shown by the ANOVA analysis. Recently, Lead is used in Pb-acid batteries, metal products such as pipes and solder, ammunitions and in devices that shield from x-rays. The concentration of Pb was lowest in excreta from Mansarover industrial area and it was its one fold in Sitapura and Jhotwara industrial area, 2-fold in Malviya industrial area, 6-fold in Vishwakarma industrial area and 18-fold i.e. highest in Sanganer industries. Some researchers have reported lead at concentration 5.753 \pm 0.676 and 12.15 \pm 3.22 ppm respectively in excreta of blue rock pigeon [5], [13]. Further, a study recorded lead at concentration of 13.82 $\mu\text{g/g}$ in the pigeon feathers. [14]. A similar study observed lead concentration range of 12.57-28.81 $\mu\text{g/g}$ in feathers of Falconidae, Accipitridae and Strigidae in Punjab, Pakistan [15]. According to [16] lead concentration of 20.59 \pm 9.07 $\mu\text{g/g}$ in jungle babbler muscles fall under the toxic category. However, Lead caused detrimental effects in birds at 4 ppm level in feathers [17]. A study categorized liver tissue with lead levels of 2–6 $\mu\text{g/g}$ to be subclinical exposure, 3-6 $\mu\text{g/g}$ to be toxic and 5-20 $\mu\text{g/g}$ to be fatal in Galliformes, Falconiformes and Columbiformes respectively [18]. Therefore, in faecal samples from Sanganer industries and Vishwakarma industrial area, lead concentration was present above these range indicate high exposure of the birds to Pb.

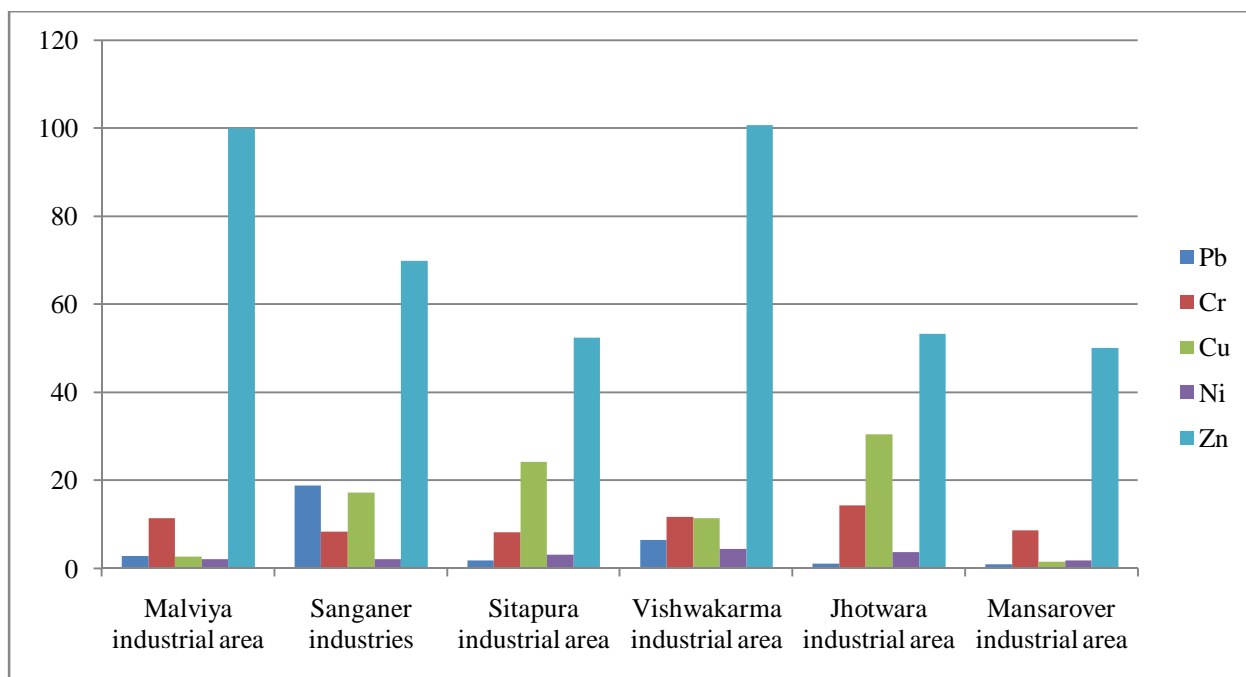


Fig.1 Mean concentration of heavy metals ($\mu\text{g g}^{-1}$) in faecal samples of pigeon from all six industrial regions

Regarding to chromium, its mean concentrations in faecal samples followed an order: Sitapura < Sanganer < Mansarover < Malviya < Vishwakarma < Jhotwara industrial area with mean values $8.25 \pm 1.44 \mu\text{g/g}$, $8.45 \pm 1.44 \mu\text{g/g}$, $8.7 \pm 2.85 \mu\text{g/g}$, $11.5 \pm 0.75 \mu\text{g/g}$, $11.8 \pm 3.41 \mu\text{g/g}$ and $14.4 \pm 0.792 \mu\text{g/g}$ respectively. Cr concentration was lowest in faecal samples from Sitapura industrial area, it was its one fold in Sanganer industries, Mansarover, Vishwakarma, Malviya industrial areas and highest in Jhotwara industrial area. ANOVA analysis had shown significance of the concentrations of Cr in the studied industrial areas at $p < 0.05$. It has been reported that industrial process such as metal plating, ceramic, glues dyes, tanning, pigments, wood preserving contribute to Cr concentration. [19]. According to [20] Cr has adverse effects on embryonic development, hatching and viability of the mallard. However, Cr concentration of $2.8 \mu\text{g/g}$ in feathers of bird has been found related with toxic effects [21]. Comparing our results with the previously reported metal data in bird's excreta, it can be noticed that lower values of Cr (6.747 ± 1.37 and 3.42 ± 0.1 ppm) has been recorded by [5], [13] respectively. A study by [22] found elevated Cr concentration ($6.6 \mu\text{g/g}$ to $7.12 \mu\text{g/g}$) in feathers of cattle egret. Therefore, Cr shows up high concentration in faecal samples from all six industrial regions.

The order of the levels of copper obtained from the six different industrial regions was Jhotwara > Sitapura > Sanganer > Vishwakarma > Malviya > Mansarover industrial area with mean values $30.55 \pm 6.58 \mu\text{g/g}$, $24.35 \pm 0.36 \mu\text{g/g}$, $17.3 \pm 5.96 \mu\text{g/g}$, $11.45 \pm 0.51 \mu\text{g/g}$, $2.78 \pm 1.08 \mu\text{g/g}$, and $1.53 \pm 0.40 \mu\text{g/g}$ respectively. ANOVA analysis showed that copper concentrations in studied industrial areas were significant at $p < 0.05$. Cu concentration was lowest in Mansarover industrial area and it was its 1-fold in Malviya industrial area, 7-fold in Vishwakarma industrial area, 11-fold in Sanganer industries, 15-fold in Sitapura industrial and 19-fold i.e. highest in Jhotwara industrial area. A study by [14] recorded copper concentration $13.15 \mu\text{g/g}$ in the feathers of the pigeons. Further, Cu concentration 20.26 ± 0.41 ppm and 14.50 ± 8.60 ppm has been observed in the excreta and plasma of *Coragypus atratus* respectively, without any lethal effect [23]. It is worth mentioned that elevated concentration of Copper can cause reproductive impairment and have also toxic effects on kidney [24]. Cooper concentration of 20.26 ± 0.41 and 38.85 ± 0.70 ppm has been found to be devoid of any toxicity, when determined in the faecal of *Coragypus atratus* and *Gallus domesticus* respectively [22]. On the other hand, [15] reported that average concentration range of copper found to be 3.38 – $28.25 \mu\text{g/g}$ in feather samples of Falconidae, Accipitridae, and Strigidae families respectively from Punjab, Pakistan.

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However, results obtained from present study were lower than those concentrations (119.47 ± 52.60 ppm and 32.35 ± 17.73 ppm) in excreta of blue rock pigeon which is recorded by [5], [13]. Copper toxicity appeared in Canada goose liver at concentration 187 - 323 μ g/g [25]. Hence present studies reveals that toxic concentration of Cu does not exist in any of excreta samples for studied industrial regions.

Concerning Ni, Level of its contamination in the excreta samples followed an order: Vishwakarma>Jhotwara>Sitapura>Malviya>Sanganer>Mansarover industrial area with mean values 4.45 ± 1.50 μ g/g, 3.85 ± 1.23 μ g/g, 3.15 ± 1.05 μ g/g, 2.25 ± 0.90 μ g/g, 2.20 ± 0.070 μ g/g and 1.90 ± 0.678 μ g/g respectively. Ni in the studied industrial areas of Jaipur showed significance at $P < 0.05$. The highest level of Ni was accumulated in Vishwakarma industrial area and this value was lower from Ni concentration (15.19 ± 1.33 μ g/g) in excreta of Black Vulture as recorded by [23]. According to [26] high concentration of Ni causes respiratory problems such as asthma, DNA damage, vomiting and birth defects. Ni level of 3.2-500 μ g/g has been present in feathers of Falconidae, Accipitridae, and Strigidae in Punjab, Pakistan [15]. Ni concentration was lowest in Mansarover industrial area and it was its 1-fold in Malviya industrial area and it was its 2-fold in Sitapura, Malviya and Sanganer industries, 3-fold in Jhotwara industrial area and highest in Vishwakarma industrial area. Nickel has many industrial uses which includes for production of stainless steel, in metallurgical, in food and chemical processing, especially as pigments and catalysts. A study conducted on feathers of cattle egret from Pakistan reported high exposure of Ni with average values range from 7.8 μ g/g to 9.0 μ g/g in eight bird species [22]. Consequentially level of Ni detected in faecal matter from studied industrial areas indicated the no risk to these species. On the other hand our results were lower to that recorded by [5], [13] and [23] who found that Ni concentration at 6.43, 9.98 and 15.19ppm respectively in bird's fecal matter.

Zinc concentration in industrial ambient air may be attributed to emission from different industrial activities e.g mining, waste and coal combustion and steel processing. The order of zinc concentrations obtained is with 100.8 ± 6.3341 μ g/g > 100.1 ± 17.0293 μ g/g > 69.95 ± 21.4733 μ g/g > 53.45 ± 12.9015 μ g/g > 52.55 ± 1.4574 μ g/g > 50.25 ± 0.3259 μ g/g mean values in Vishwakarma, Malviya, Sanganer, Jhotwara, Sitapura and Mansarover industrial area respectively. ANOVA analysis showed that zinc concentrations in studied industrial areas were significant at $p < 0.05$. As in case with Cu and Ni, Zn concentration was lowest in excreta samples from Mansarover industrial area and it was its 1- fold in Sanganer, Jhotwara and Sitapura industrial area, 2- fold in Malviya industrial area and highest in Vishwakarma industrial area. The maximum level of zinc recorded by [5], [13] in excreta of blue rock pigeon were 154.17 ± 12.18 ppm and 196.94 ± 113.53 ppm respectively. Zn concentration of 48.49-294.3 μ g/g has been recorded in feathers of three families of bird in Punjab, Pakistan [15]. However, [14] found Zinc concentration 204.80 μ g/g in pigeon's feathers. It is worth mentioned that our results for zinc were lower than [23] who observed Zn concentration 202.57 ± 1.65 μ g/g in excreta of Black Vulture. Thus, in faecal samples from studied industrial area, Zinc concentration does not exist in toxic range indicates low risk of Pb to birds.

IV. CONCLUSION

The outcomes of the present investigation demonstrate pigeons are good bioindicator for heavy metal pollution due to presence of high concentration of Pb and Cr in its excreta. This study revealed that the industrial environment of Jaipur city suffer environmental problems, such as contamination with Pb, and Cr at various levels. According to [27] urban and industrial regions do not only add pollutants but they are also characterized by a high pollutant input consisting of numerous xenobiotics from many different sources. The present study showed that the level of heavy metals was higher and some are of above the permissible limit in the pigeon excreta. Hence this indicates industries in studied industrial regions make use of the Chromium and lead in several ways. The utilization cannot be fully abolished due to modernization but it can be checked and many avian species can be preserved.

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