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Metal contamination in mammalian fauna of Sariska tiger reserve, Alwar, India

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Abstract :*Many of the factories spewing pollutants are located too close to the wildlife reserves and metal roads are laid traversing through these protected areas. The traffic of automobiles is unmindful of the inconvenience to the wildlife and the pollution threatening the fauna. The wildlife harboured in these reserves are at the risk of getting exposed to automobile exhaust, industrial gases and suspended particulate matters. Anthropogenic activities near or within the wildlife habitats are threatening the wildlife with exposure to a variety of environmental contaminants. Restrictions on the sampling because of Wildlife Protection Act (1972) prevents taking of samples of living tissues to analyse body burdens of contaminants that the wildlife may be carrying. Fecal matter samples of wild mammals, vegetation, soil and water of Sariska Tiger Reserve, Alwar, Rajasthan showed good concentration of heavy metals (Pb, Cd, Cr, Cu and Zn).*

Keywords : Pollution, Heavy metals, Bioindicator, Feces, Wild mammals, Sariska Tiger Reserve.

Introduction

Several studies have reported concentrations of metals in wild mammals living in highly contaminated areas near smelters (Beyer *et al.*, 1985), chlor-alkali plants (Dustman *et al.*, 1972; Wern, 1985), verges of heavily-used highways (Clark,1979) and mines or mine-waste sites (Andrew *et al.*, 1984). Sariska Tiger Reserve is situated in the northern part of the Aravali hills, nearly 200 kms from Delhi on the Delhi-Alwar-Jaipur road. An area of 800 sq kms, Sariska was declared a sanctuary in 1955 and it became a tiger reserve in 1979. The Aravali range-sharp-hog-backridges are conspicuous in the reserve. Most of the high ridges are composed of quartzite. There are various roads which pass through the sanctuary. Most of the samples were collected on road connecting Sariska to Pandupole and two other roads namely Tehla-Sariska and Alwar-Thanaghazi roads. Traffic is particularly heavy on Tuesdays and Saturdays as thousands of vehicles, both private and public vehicles, take the pilgrims to the temples located near Pandupole. However, Thanaghazi-Alwar and Sariska-Tehla are regular bus routes. All these activities result in heavy metal pollution, which may adversely affect the health and wellbeing of the wild animals.

Various methods were employed to assess and draw a concentration profile of a variety of pollutants that might reach the wildlife habitats and wildlife itself. In one such study rats, captured from either side of the highways indicated that the body concentration of the lead was directly proportional to the distance from the highway (Way and Schroder, 1982). Bat was the first mammal used by analysis of its guano as bio-indicator for pesticidal pollution as well as mercury exposure (Reidinger, 1972; Petit and Altenbach, 1973; Clark *et al.*, 1982) and analysis of feces for Cd intake in humans (Kjellstrom *et al.*, 1978). Sileo and Beyer (1985) recorded concentration of cadmium, lead, zinc, copper in the feces of deer killed near smelters to check the degree of metals pollution.

A pilot study to monitor lead contamination in wild herbivores from the protected areas of Rajasthan, India (Gaumat and Bakre, 1998) suggests that exposure to heavy metals can be studied using herbivore dung as a bio-indicator. In the continuation of this, study was also done

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in mammalian fauna of Keoladeo National Park, Bharatpur (Gaumat and Bakre, 2001). Scat samples of the mammals, vegetation, and soil samples clearly indicate the extent to which the mammalian fauna is exposed to metal contamination.

However, the method of sacrificing or killing of animal may appear more scientific, but is certainly ethically unsound. Given the concern for loss of animal lives for scientific investigation, and the increasing biological poverty of the planet earth, there is an urgent need for developing biological indicators which will not involve killing of animals. To overcome this problem it was proposed to use feces / scat / fecal matter as bio-indicators to study exposure of wildlife to heavy metal contamination.

Materials and Methods

In the field (Sariska Tiger Reserve) scat sampling was totally opportunistic type. Fresh scat samples of wild mammals of reserve were collected with the help of forest staff from different sites. The sites were selected as near the roadside (disturbed area) and distant from roadside (undisturbed area). These sites were Alguaal area, Bramnath, Daura-Ka-Johra, Kalighati, Nayapani, and Slopka. Samples were brought to the laboratory and kept in freeze for metal analysis. Scat samples of the following mammalian species were collected; Chital.,*Axis axis*, Nilgai., *Boselaphus tagocamelus*, Porcupine., *Hystrix indica*, Hare, *Lepus nigricollis*, Rhesus monkey.,*Macaca mulatta*, Sambar., *Cervus unicolor*, Wildboar., *Sus scrofa*, Tiger., *Panthera tigris.* To ascertain the source of contamination water and vegetation samples of this park were also collected. Another, suspected source of contamination was suspended particulate matter settling on the ground, hence soil samples were also taken from different roadsides of park. Scat and soil samples were stored in the plastic zip-lock bags and water samples in the sterilized plastic containers.

For analysis of sample 0.5 gm of dry scat / vegetation / soil were weighed and taken in the hard Borosil glass tube. Concentrated nitric acid and perchloric acid were added to each sample in 4:1 ratio. Sample was kept in water bath for 5 to 6 hours or until it was digested completely and became clear. When the sample was clear 3 to 4 drops of H_2O_2 (30%) were added to neutralize and to dissolve the fat. After cooling each sample was diluted upto 10 ml with deionized water and transferred to sterilized Borosil glass vial and stored at room temperature prior to analysis.

Water samples were transferred into beakers, cleaned with double distilled water, and concentrated keeping on a hot plate in a flame hood adding 12 to 15 ml of analytical grade HNO_3. The heating was continued till such time the sample became colorless and clean. However, samples were never allowed to dry completely. By and large, nitric acid alone was adequate for complete digestion of water samples. $HClO_4$ was added only to those samples which had high organic matter which were always treated in advance (pre-treated) with nitric acid before adding perchloric acid. If necessary, more HNO_3 was added and volume brought down to the lowest quantity (10 to 25 ml) before precipitation occurred. After completing the digestion, beakers were allowed to cool. Samples were diluted upto 10 ml with double distilled water.

Entire metal analysis was done by using GBC Advanta ver. 1.31 Atomic Absorption Spectrophotometer at 217 nm for lead, 228.9 nm for cadmium, 324.7 nm for copper, 213.9 nm for zinc and 357.9 nm for chromium. Results are presented in µg/g (ppm) dry weight and µg/ml (ppm) wet weight.

Results and Discussion

The fecal matter / scat sample analysis shows the presence of lead (Pb), cadmium (Cd), chromium (Cr), copper (Cu), and zinc (Zn) in varying concentrations. Lead was observed in the range of 2.65 to 25.58 ppm d/w in the scat of wild mammals from the areas in the varying distances from metal roads. Concentration of lead was found in descending order as follows in different mammals. In Chital, *Axis axis* , it was Slopka > Kalighati > Nayapani > Bramnath > Daura Ka Johra > Alguaal area. In case of Nilgai, *Boselaphus tagocamelus* the lead values in descending order were Kalighati > Slopka > Daura Ka Johra > Alguaal area > Bramnath > Nayapani. In Porcupine *Hystrix indica* it was Kalighati > Slopka > Bramnath > Nayapani. In case of Rhesus monkey, *Macaca mulatta* lead was found to be greater in slopka area than in kalighati. Lead content in Tiger, *Panthera tigris* was higher in kalighati which was followed by slopka region. Similarly Sambar, *Cervus unicolor* and Hare, *Lepus nigricollis* also showed good concentration of lead. However, scat of all species were found only in certain areas but in others scats of only certain species were found. These values show that most of the wildlife species from Slopka and Kalighati areas of park had good concentration of lead.

The concentration of cadmium was found in the range of 0.87 to 3.51 ppm d/w in mammalian scat. Concentration of cadmium was found in descending order in Chital, *Axis axis* , it was Slopka > Nayapani = Alguaal area = Bramnath > Kalighati > Daura Ka Johra. In Nilgai, *Boselaphus tagocamelus* was Slopka > Nayapani = Bramnath > Kalighati > Alguaal area > Daura Ka Johra. In Porcupine *Hystrix indica* it was Slopka > Nayapani = Bramnath > Kalighati. Similarly cadmium in Tiger, *Panthera* tigris from Slopka was higher than from Kalighati. However, cadmium was also found in Sambar, *Cervus unicolor* and Wild boar, *Sus scrofa* from Nayapani region. Whereas cadmium was detected in Hare, *Lepus nigricollis* from Bramnath area.

Chromium was detected in the range of 2.09 to 16.12 ppm d/w in the scat of wild mammals of park. The concentration of copper analysed in scat of mammals collected from different distances from metal roads in park were observed in range of 0 to 11.23 ppm d/w. Zinc was estimated in the range of 17.7 to 48.18 ppm d/w in scat samples of park.

The analysis of soil and water indicates that lead was present in considerable amount which shows the greater concentration of air borne lead which might have settled down on soil surface. Water also had good concentration of lead. Cadmium concentration found in water was in trace amount i.e. below detectable limit whereas soil also had lower amount of cadmium. Good concentration of chromium was found in water as well as in soil. Copper was also found in water and soil samples. The amount of zinc was much higher in soil than water where it was below detection limit.

Lead was also analysed in Cassia (tree) samples from the roadside. The high concentration of lead indicates the arial deposition of lead on the leaves of trees,whereas cadmium was found to be in less amount. Chromium was also found in vegetation samples. Copper is known as essential metal which was also found in Cassia. Zinc was found below detectable limit in Cassia.

Heavy metals concentrations were found in considerable amount in the biological samples collected from Sariska Tiger Reserve, Alwar. Scat of the mammalian species reported here were all opportunistic samples. Reserve is fragmented because of the presence of metal roads running right through the sanctuary. In fact heavy traffic can be seen on Tahla-Sariska and Alwar-Jaipur road which is a daily routine affair. However, on Tuesday and Saturday there is no ban on the entry of vehicles inside the park. As a result literally thousands of two and four wheelers enter the sanctuary to reach Pandupole. These vehicles passing through the thick forest are all the time emitting exhaust laced with particulate matter containing metals. This smoke spewed by overloaded vehicles has no escape route out of the sanctuary where it remains suspended for a considerable time. It is likely to be inhaled by the animals, particularly herbivores feeding close to the road. After remaining suspended for some time the particulate matter, with the cooling of the air, starts settling down gradually on the vegetation, soil and water bodies. As a consequence apart

S.N.	Species	N	Pb (ppm) Mean±S.D.	S.E.	Cd (ppm) Mean±S.D.	S.E.	Cr(ppm) Mean±S.D.	S.E.	Cu(ppm) Mean±S.D.	S.E.	Zn(ppm) Mean±S.D.	S.E.
	Scat of Wild Mammal											
A	Alguaal Area											
1	*Axis axis*	10	15.59 ±2.62	0.83	1.26±0.05	0.018	11.0±0.41	0.28	4.4±0.37	0.11	23.15±0.76	0.24
2	*Boselaphus tragochamelus*	9	18.06±1.81	0.60	1.13±0.03	0.015	12.1±1.09	0.85	3.31±0.93	0.31	29.01±1.09	0.36
B	Bramnath											
1	*Axis axis*	15	18.58±1.38	0.35	1.26±0.05	0.016	8.5±0.19	0.07	4.30±0.27	0.06	25.99±1.81	0.45
2	*Boselaphus tragocamelus*	25	17.24±1.16	0.23	1.52±0.08	0.059	*2.09±1.77	1.25	10.91±0.13	0.02	38.42±1.51	0.30
3	*Hystrix indica*	31	14.18±2.88	0.49	1.46±0.20	0.004	2.92±0.40	0.08	#11.23±1.97	0.33	29.90±1.15	0.20
4	*Lepus nigricollis*	19	9.84±1.10	0.32	1.09±0.07	0.021	4.76±2.2	1.58	3.76±0.85	0.25	18.16±0.75	0.22
C	Daura Ka Johra											
1	*Axis axis*	29	18.46±1.47	0.27	*0.87±0.03	0.01	5.68±0.82	0.57	*ND	-	19.28±1.61	0.30
2	*Boselaphus tragocamelus*	15	19.82±2.5	0.50	0.90±0.04	0.021	*2.09±0.35	0.07	2.33±2.06	0.41	32.45±1.1	0.22
D	Kalighati											
1	*Axis axis*	10	23.86±2.6	0.82	0.94±0.04	0.015	9.11±0.09	0.03	3.91±0.3	0.11	23.11±3.81	1.22
2	*Macaca mulatta*	15	18.11±1.69	0.43	0.90±097	0.03	4.48±1.06	0.74	3.70±0.04	0.01	*17.7±1.09	0.28
3	*Boselaphus tragocamelus*	29	22.96±1.2	0.04	1.32±0.05	0.016	8.84±1.14	0.80	5.94±0.53	0.09	25.51±1.0	0.18
4	*Hystrix indica*	15	#25.58±1.9	0.49	1.31±0.09	0.031	5.31±0.31	0.11	10.41±0.27	0.06	20.9±1.89	0.48
5	*Panthera tigris*	10	18.12±2.89	0.91	2.57±0.17	0.05	5.08±1.58	0.5	2.1±0.05	0.015	34.8±1.12	0.35
E	Nayapani											
1	*Axis axis*	25	19.22±1.66	0.33	1.26±0.56	0.281	3.63±0.89	0.62	3.66±0.58	0.115	25.18±0.98	0.19
2	*Boselaphus tragocamelus*	32	*2.65±173	0.30	1.52±0.18	0.06	5.98±0.22	0.15	4.59±0.61	0.1	27.4±1.19	0.21
3	*Hystrix indica*	24	11.68±1.87	0.48	1.46±0.20	0.06	7.8±2.06	1.45	9.69±1.48	0.38	28.4±2.16	0.55
4	*Cervus unicolor*	31	12.76±3.33	0.59	1.09±0.06	0.021	#16.12±0.98	0.31	5.59±0.51	0.09	24.46±3.33	0.59
5	*Sus scrofa*	28	16.96±1.28	0.24	0.88±0.06	0.021	4.51±1.5	1.01	10.2±1.55	0.29	41.9±3.13	0.57
F	Slopka											
1	*Axis axis*	35	25.15±1.99	0.33	1.56±0.98	0.215	8.69±0.93	0.61	3.98±0.73	0.12	23.18±1.4	0.23
2	*Boselaphus tragocamelus*	31	21.09±0.85	0.15	1.34±1.10	0.912	7.03±0.59	0.31	5.82±0.53	0.09	21.08±0.99	0.17
3	*Macaca mulatta*	16	20.12±1.56	0.39	1.93±0.11	0.02	2.67±0.11	0.07	3.73±0.04	0.01	19.18±1.21	0.03
4	*Hystrix indica*	19	24.11±0.68	0.15	1.51±0.73	0.015	5.13±1.16	0.99	10.11±1.09	0.2	#48.18±3.9	0.74
5	*Panthera tigris*	12	12.64±2.43	0.7	#3.51±0.85	0.341	2.43±0.63	0.31	2.10±0.93	0.26	40.9±4.14	1.19
	Vegetation											
1	Cassia	22	14.02±2.54	0.54	1.62±0.08	0.002	4.15±0.95	0.38	18.98±1.86	0.39	32.7±1.15	0.24
	Water**	10	17.02±2.52	0.79	ND	-	0.83±0.09	0.008	9.09±3.86	1.22	ND	-
	Soil	19	13.16±0.98	0.22	1.10±0.12	0.03	12.19±1.81	0.99	15.12±0.19	0.04	20.31±0.62	0.14

N=Number of samples, ND= Not detectable, * =Lowest Mean values, # = Highest Mean values, Metal concentration in µg/g (ppm) dry weight and **µg/ml (ppm) wet weight.

from inhalation, wild animals are exposed to metals through food and water. The thick vegetation ensures limited movement of exhaust from the point of emission. Some of the samples were also collected from the metal roads and deeper into wooded areas. Obviously roadside samples have higher concentrations of lead and other metals compared to those from deeper forest. Thus the mammalian fauna are exposed to metal contamination though variety of routes.

Leonzio and Massi (1989) had shown that metal concentration in feces normally equals that in food. Obviously the additional exposure was through plausible route of inhalation. The load of lead in fecal matter almost exceeded than what is present in the food material. Earlier studies have quantified deposition of metals in the vicinity of the highway or traffic dense area, either by measurement by dry deposition fluxes at various distances from road, or by calculating soil and vegetation concentrations and assuming that the soil acts as long-term store, hence effectively integrating the deposition (Little and Wiffen, 1977,1978**)**. Lead concentrations as high as 6835, 1180 and 682 ppm dry weight have been reported in soil, vegetation and invertebrates, respectively (Williamson and Evans, 1972, Little and Wiffen, 1978).

Metals belong to the group of foreign materials that are excreted into bile and their ratio of concentration in bile verses plasma is greater than 1.0 and may be as high as 10 to 1000. Since liver is in a very advantageous position for removing toxic materials from blood after their absorption, it can prevent their distribution to other parts of the body. Furthermore, because the liver is the main site of biotransformation of toxic agents the metabolites may be excreted into bile (Klaassen, 1976**)**. Lead is absorbed in gastrointestinal tract by two steps. It is first absorbed from lumen and then excreted into the intestinal fluid (Sobel *et al.* 1938). Upon oral ingestion about 5 to 10 % of lead is absorbed and usually less than 5% of what is absorbed is retained (Goyer, 1986). Thus about 99.5 % of total ingested lead is excreted through feces. Out of this 90% is coming out without being absorbed and 9.5% after being absorbed and metabolized leaving only 0.5% to be deposited in various body tissues.

Our study has firmly established the value of fecal matter analysis as bioindicator of heavy metal contamination. At least our study holds out a promise where scat can be used, since it does not involve either disturbing or killing of an animal, particularly wildlife in protected areas.

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