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Bat guano: a rich source of macro and microelements essential for plant growth

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ABSTRACT

Bats are unique among mammals, widely distributed and often live gregariously. The bat guano is being used traditionally as natural fertilizer. The present study was carried out to examine the nutritional value of different species of insectivorous bat guano and validate over vermicomposting. Elemental compositions of bat guano belong to six insectivorous bats such as R. hardwickii, R. microphyllum, S. heathii, S. kuhlii, T. nudiventris and M. lyra were analyzed using SEM-EDS and compared with the elements of vermicompost. The guano of insectivorous bats such as S. heathii, S. kuhlii, R. hardwickii, M. lyra and R. microphyllum showed high contents of elements such as N, K, Ca, P, Na, Cl, S, Al, Fe, Mg and Si. The elemental composition of the vermicompost did not show the traces of Cl, S and Ti. The highest content of nitrogen was observed in the guano of insectivorous bat R. microphyllum (11.17 %) while highest contents of Ca (5.74%) and P (6.17%) were found in a carnivorous bat, M. lyra. The abundant source of nutritive elements in the bat guano suggests its suitability as organic manure. Further, the elemental composition in the bat guano is the nutritive source for the growth of microbiota in the cave ecosystem.

Keywords: Bat guano, Micro and macronutrients, Insectivorous bats, Vermicompost, SEM-EDS

INTRODUCTION

Bats are ubiquitous and play vital role in ecological balance, nutrients cycling and redistribution of forests. Nutritional studies of bats have dealt with energy or water demands (Bassett and Studier, 1988), only few studies of insectivorous bats guano were carried out on nitrogen and mineral budgets (Studier *et al.*, 1994a,b). The bat guano is being widely used as a natural fertilizer due to its high nitrogen content and also the guano shows some nematocidal effects (Keleher and Sara, 1996). The bat guano is also very important for the growth of microflora as it contains all essential nutritive elements for their growth. Unfortunately, the bat guano was ignored and chemicals fertilizers became the nutritional source of plants. The use of chemical fertilizers and pesticides in modern farming enhanced the food productivity but deteriorated soil and environment conditions which in turn affect the human health and environment. The use of vermicompost for sustainable agriculture is very important because it contains beneficial microorganisms, macro and micro-nutrients, enzymes and hormones. Vermicompost has a desirable aesthetics like reduced levels of contaminants (Ndegwa and Thompson, 2001). Although, the bat guano is being used at different regions as organic manure since long, the nutritive values, and existence of macro and microelements of bat guano still lacking. Therefore, this study was aimed to investigate the nutritional values of guano belong to different species of insectivorous bats such as *Rhinopoma hardwickii*, *R. microphyllum*, *Scotophilus heathii*, *S. kuhlii*, *Taphozous nudiventris*, *Megaderma lyra* and *Hipposideros fulvus*, and compared with the vermicomposting.

MATERIALS AND METHODS

The present study was carried out between June 2012 and May 2015. The guano samples of *R. hardwickii*, *R. microphyllum*, *S. heathii*, *S. kuhlii*, *T. nudiventris*, *M. lyra* and *H. fulvus* were collected by spreading 2 x 2 m polythene sheet beneath their roosting sites. Guano sample of bats were collected from Balister Singh, Purwa, Unnao (26°26'47"N, 80°44'19"E), Rafi Ahmad Kidwai Inter College, Hardoi (27°18'31"N, 82°32'33"E), Allipur, Kashipur villages and Railway station of Hardoi (27°24'83"N, 80°06'42"E), Babasaheb Bhimrao Ambedkar University campus, Lucknow (26°46'01"N, 80°55'12"E), Atala mosque, Jaunpur (25°44'57"N, 82°41'04"E), Diyara, Sultanpur (26°13'01"N, 82°14'46"E), Jhansi Fort, Jhansi (25°27'20"N, 78°34'54"E), and King Rudra Pratap Singh Shahi palace, Kal Kothary,

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Chunar Mirzapur (25°06'10"N, 82°52'22"E), Thar Ganga Ghat, Varanasi (25°18'45"N, 83°00'57"E), Jhushi fort and Khusurubagh fort, Allahabad (25°26'47"N, 81°48'58"E), Bhuragrah fort, Banda (25°28'34"N, 80°18'11"E), Gupt Godavari, Chitrakoot (25°05'54"N, 80°46'06"E). Guano samples were stored in 5 ml sample vials and kept in the refrigerator (4°C) until the analysis. Vermicompost was procured from the Biotech Park, Lucknow, Uttar Pradesh. The aseptically collected guano samples and vermicompost were kept in desiccators overnight for removal of moisture. The samples were coated with palladium sputter coater and analyzed under Scanning Electron Microscope (JEOL JSM 6490 LV, Japan) at different accelerating voltage. Scanning Electron Microscope equipped with energy dispersive X-ray spectroscopy (Oxford INCA) was used for elemental analysis. Each sample was subjected to three-points analyses. In addition, the nitrogen contents of samples were analyzed by following Kjeldahl method.

Statistical analysis

All statistical analyses were performed in SPSS (version 20). We set the null hypothesis, H_o: differences of elements in different bats guano were equal. i.e. $p_{1=}$ p_1. We also set alternate hypothesis, H_1: differences of elements in different bats guano were not the same. i.e. $p_1 \neq p_1$. Differences between the elements of bats guano samples were evaluated with ANOVA followed by a *posteriori* Tukey test (Zar, 1999). The unpaired *t*-test was used to determine possible differences between the bat guano and vermicompost. The level of statistical significance was $p \leq 0.05$. Graphs were prepared using Graph-Pad Prism (Version 5).

RESULTS AND DISCUSSIONS

The results of the present study revealed that the guano of bats contained a wide range of mineral constituents including macronutrients and micronutrients. A total of 12 elements such as aluminium, calcium, chlorine, iron, potassium, magnesium, sodium, phosphorous, sulfur, silicon and titanium were found in different species of bat guano (Fig. 1). Beside these elements, boron, manganese, copper, zirconium and zinc were also found but in trace amounts. On an average, oxygen was the most abundant element found in the guano (54.94%) while Ti (0.38%) was the least abundant element (Fig. 1).

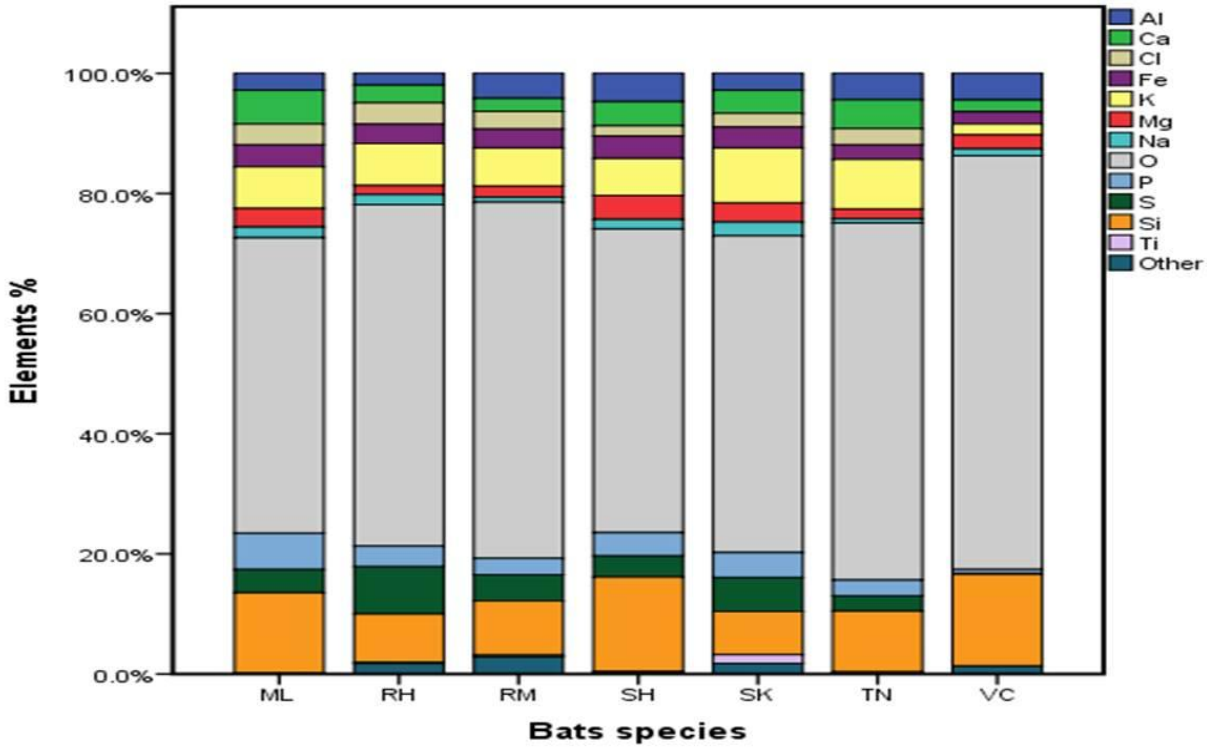

Figure 1: Percent elemental share in the guano of different species of insectivorous bats and vermicompost

Though, the elemental composition of the guano varied among different bat species, the highest percentage of elements such as Al (4.76), Fe (3.76), Mg (4.05) and Si (15.91) were observed in the guano of *S. heathii*, while higher compositions of K (9.18) and Na (2.29) found in *S. kuhlii* (Fig. 2, Table 1). The guano of *R. hardwickii* showed highest percentage of Cl (3.57%) and S (7.86%), while the guano of carnivorous bat *M*. *lyra* showed more Ca (5.74%) and P (6.17%). The elemental composition of the vermicompost did not show the traces of Cl, S and Ti. However, the most abundant element apart from oxygen in the vermicompost was Si (15.05%). Statistically, there was no significant difference in the elemental compositions among the guano of bats and vermicompost (Table 1). Further, an unpaired t-test also revealed non-significant difference between the elemental composition of bat guano and vermicompost, except phosphorus ($t = 3.89$, $p < 0.05$). Results showed that the guano of all six insectivorous bats showed high differences in their nitrogen contents. The nitrogen content was high in the guano of *R. microphyllum* (11.17 %) while it was very low (0.73%) in *R. hardwickii*. In the guano of *S. kuhlii*, *T. nudiventris*, *M. lyra* and *S. heathii* the nitrogen contents were 9.95 %, 6.38 %, 5.45 % and 2.57 %, respectively.

Table 1: Elemental composition of different species of bat guano. The values are given as Mean ± SD

Species	RH	RM	SH	SK	TN	ML	VC	ANOVA	
Elements %								F	p
AL	1.93 ± 2.43	4.16 ± 5.92	4.76 ± 4.86	2.80 ± 2.63	4.37 ± 3.56	2.83 ± 2.83	4.33 ± 2.32	(6,68) = 0.872	0.520
Ca	2.95 ± 4.55	2.17 ± 2.43	4.08 ± 6.35	3.86 ± 5.44	4.81 ± 6.64	5.74 ± 5.39	1.95 ± 0.72	(6,67) = 0.722	0.633
Cl	3.57 ± 4.30	2.95 ± 3.38	1.74 ± 2.50	2.31 ± 1.51	2.71 ± 3.57	3.54 ± 4.36	-	(5,67) = 0.507	0.770
Fe	3.20 ± 4.14	3.11 ± 3.11	3.76 ± 3.21	3.49 ± 4.72	2.41 ± 3.62	3.69 ± 5.37	1.97 ± 1.48	(6,69) = 0.164	0.985
K	7.00 ± 4.96	6.34 ± 4.99	6.25 ± 4.20	9.18 ± 8.05	8.29 ± 5.45	7.07 ± 4.83	1.79 ± 0.45	(6,69) = 0.924	0.483
Mg	1.49 ± 1.57	1.84 ± 1.78	4.05 ± 3.95	3.20 ± 1.97	1.62 ± 1.41	3.11 ± 2.96	2.28 ± 0.43	(6,68) = 1.765	0.120
Na	1.68 ± 1.56	0.83 ± 0.86	1.62 ± 1.84	2.29 ± 2.14	0.70 ± 0.84	1.82 ± 1.53	1.11 ± 1.69	(6,69) = 1.501	0.191
O	56.84 ± 12.37	59.30 ± 14.21	51.28 ± 10.16	52.84 ±12.54	59.44 ± 13.39	49.97 ± 8.58	67.60 ± 9.00	(6,69) = 1.759	0.121
P	3.43 ± 3.08	2.74 ± 3.73	3.97 ± 7.29	4.20 ± 3.79	2.63 ± 2.46	6.17 ± 5.65	0.75 ± 1.30	(6,68) = 1.131	0.354
S	7.86 ± 6.78	4.35 ± 3.85	3.54 ± 5.11	5.64 ± 3.27	2.52 ± 2.40	3.89 ± 2.96	-	(6,67) = 2.259	0.058
Si	8.09 ± 9.19	9.04 ± 9.75	15.91 ± 16.02	7.22 ± 6.57	13.62 ± 16.01	15.05 ± 8.87	15.05 ± 8.87	(6,69 = 0.898	0.501
Ti	0.17 ± 0.52	0.28 ± 0.52	0.23 ± 0.27	1.47 ± 4.91	0.11 ± 0.32	0.06 ± 0.13	-	(6,68) = 0.679	0.667
Others	1.75 ± 3.06	2.85 ± 3.13	0.24 ± 0.51	1.76 ± 4.08	0.22 ± 0.66	0.08 ± 0.30	1.27 ± 2.19	(6,69) = 1.801	0.112

Note: RH = *R. hardwickii*, RM=*R.microphyllum*, SK=*S. kuhlii*, SH=*S.heathii*, TN=*T.nudiventris*, ML=*M.lyra* and VC=vermicompost

The macro-nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium and sulfur were abundant in the bat guano. It has been already reported that guano of *Hipposideros speoris* amended in soil at a ratio of 1:20 serves as a good fertilizer (Sridhar *et al.*, 2006). Bat guano also serves as soil builders, nematicidal (Keleher and Sara, 1996), compost activator and improved the quality of poor roughage (Paul and Sagamiko, 2008). Studies on *Eptesicus fuscus* indicate that insects are inadequate sources of calcium, excellent sources of nitrogen and magnesium, marginal sources of potassium, iron, and sodium (Studier

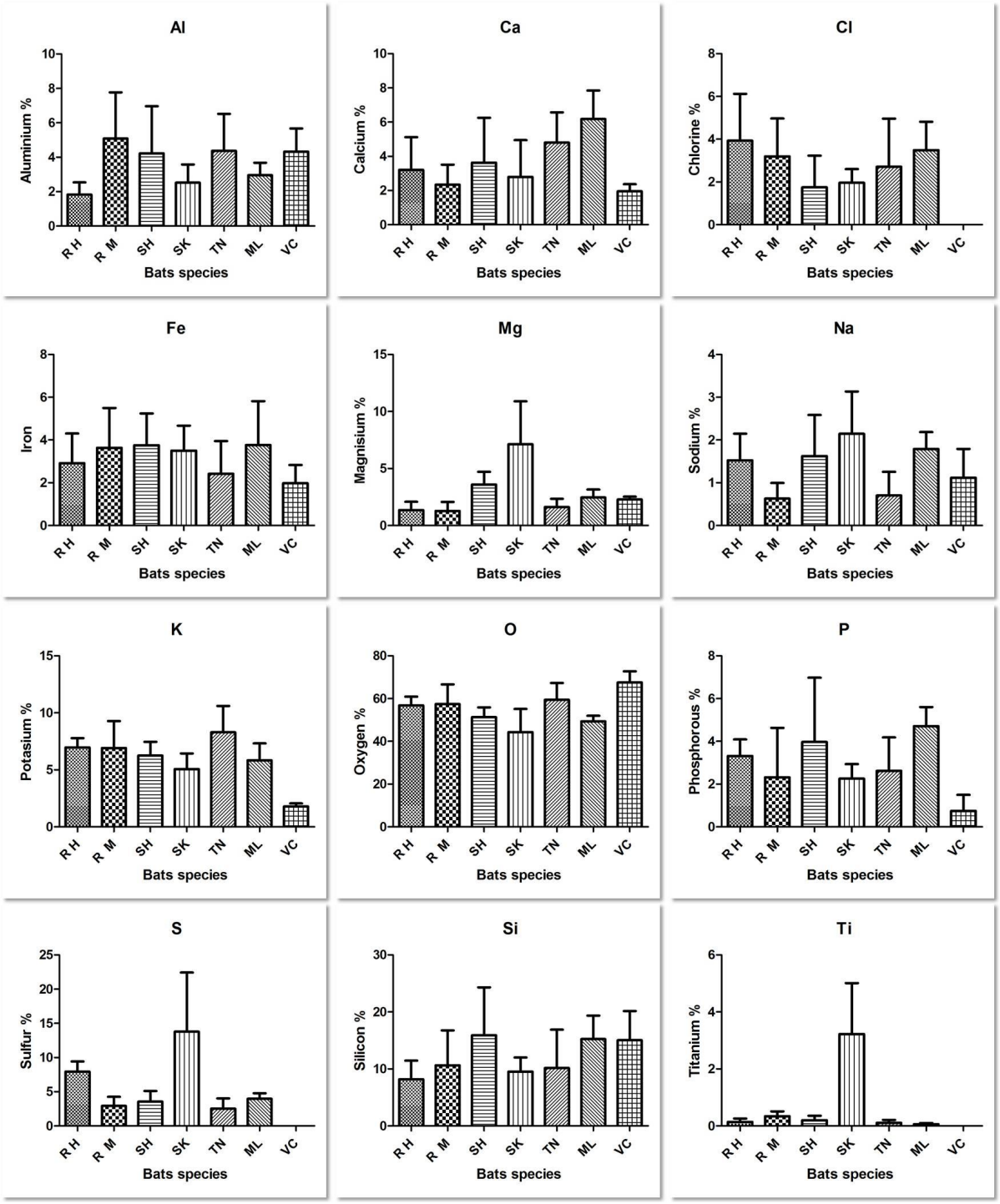

Figure 2: Macronutrients (%) – P, K, Ca, Mg, S, and Si, and micronutrients (%) Al, Cl, Fe, Na, and Ti of different species of bat guano. RH = *R. hardwickii*, RM = *R. microphyllum*, SK = *S. kuhlii*, SH = *S. heathii*, TN = *T. nudiventris*, ML = *M. lyra* and VC = vermicompost

et al., 1994a,b), the current study reflects similar outcome. The percentage of nitrogen varied among six insectivorous bat guanos. Guano of *R. microphyllum* showed highest percenrage of nitogen while a least quantity was observed in the guano of *R. hardwickii*. Nitrogen percentage in the guano of *S. kuhlii*, *S. heathii* and *T. nudiventris* were almost constant, not much

variation found as in *R. microphyllum* and *R. hardwickii*. Sodium and potassium were highest in the guano of *S. kuhlii* and presence of high-level potassium suggests that they consume a large amount of lepidopteron insects (Studier *et al.*, 1994a,b). In the present study, the percentage of calcium was ranged from 1.95 to 5.74 compared to an earlier observtion stated that calcium was inadequate source in the guano of insectivorous bats (Studier *et al.*, 1994a,b). Presence of sufficient quantity of calcium in the guano of insectivorous bats indicates their diverse feeding habits.. Among the guano of six bat species the highest percentage of P was observed in the guano of *M*. *lyra* and the phosphorus contents in the bat guano were much higher than the vermicompost. Chlorine was found in the guano of almost all the bat species. Magnesium (Mg) was found in all the guano samples of all six insectivorous bats except *R. microphyllum* and their percentage was also sufficient. Sulphur present in all six insectivorous bats guano, but the highest percentage of S was observed in the guano of *R. hardwickii*, while absernt in vermicompost.

Therefore, the abundant source of macro-nutrients in the bat guano and the presence of higher amount of nitrogen and phosphorous suggest its suitability as organic manure. The results of the study showed the presence of wide range of elements in the guano of different species of bats. Along with its higher fertilizing value, use of guano as a fertilizer can become popular like other non-conventional organic manures in agriculture. It is known fact that varying amount of nitrogen and phosphorus in the guano of bats can be used for differential growth of plant parts. It prompted a novel suggestion to use of guano from selected groups of bats as fertilizer in selective crops to enhance the production and quality.

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