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SOIL PHYSICO - CHEMICAL PROPERTIES OF DRIED PONDS OF VARANASI (INDIA)

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RESUME

La présente note étudie les propriétés physico-chimiques des sols d'étangs séchés à Bénarès (Inde). Les sols sont argileux et présentent une capacité élevée de rétention de l'eau. La teneur en matière organique et en éléments minéraux fut déterminée en vue de définir la valeur nutritive de ces sols. La teneur en N maximale fut observée en décembre (0,17 %), le rapport C/N variant de 5,4 à 15,3 selon les stations étudiées. La teneur en phosphore varie sensiblement (de 129 à 292 ppm). Les cations échangeables sont sous la dépendance du régime hydrique et montrent des variations mensuelles élevées. Les cations totaux échangeables peuvent atteindre 22,05 m.e. %. Les sols sont acides, à de rares exceptions près, qui montrent une tendance vers des caractères neutre ou salin.

ABSTRACT

The present paper deals with the physico-chemical properties of the soils of dried ponds of Varanasi (India). The soils are clayey and thereby show high water holding capacity. Organic matter and mineral elements were determined to explore the nutrient capital of dried pond soils. Maximum nitrogen was recorded 0.17 % in the month of December and C/N ratio varied from 5.4 to 15.3 among the three sites undertaken for this study. Phosphorus content in the soils ranged from 129 to 292 ppm. Exchangeable cations varied greatly under the different regime of moisture stress in different months. Total exchangeable cations reached up to the level of 22.05 m.e. %. The soils are generally acidic, with few exceptions of saline and neutral character.

INTRODUCTION

The dried ponds present a very heterogenous environment due to variations in size, duration of inundation and local edaphic and biotic factors. Therefore they need a careful study of their response to the

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existing vegetation. The recurrence of plant in such habitats with fluctuating soil factors from water logged to hard conditions raises interesting problems with regards to physiological and ecological equipment of the species growing there upon. Such ponds change rapidly. It is difficult to determine what the normal ecological factors and events are in the drama of an ecosystem with such "internal complexity" and such "bewildering variation". Studies on the ecology of such ponds have been mainly descriptive (MISRA, 1946; RATNAM & JOSHI, 1952; MALL, 1953; BARCLAY, 1966). Hence it is interesting to study the physico-chemical properties of soils of dried ponds.

Ponds are normally classified with respect to seasonal duration either as temporary ponds which dry up during the year or permanent ones which retain water all the year round.

MATERIAL AND METHODS

The present study extends over three temporary ponds of Varanasi (25° 18' latitude N and 83° 1' longitude E), in the eastern part of the upper Gangetic plain about 252 m above sea level. Two ponds (sites I and II) are situated in the Banaras Hindu University campus and the third one (site III) is located near Sarnath Railway Station. These ponds were observed from December 1976 to June 1977.

Composite soil samples were taken from each pond up to 30 cm depth for each month. Soil samples were mixed and gently ground in a mortar and passed through 2 mm sieve and were stored in polythene bags.

Mechanical analysis, water holding capacity, bulk density, porosity and organic matter were done after the methods given by PIPER (1966). The pH is determined through electric pH meter. The available phosphorus in the soil was determined by the method described by JACKSON (1958). Sodium, potassium, calcium were estimated by flame-photometer. Total exchangeable cations (T.E.C.) was determined by HCl extraction method as described by JACKSON (1958).

RESULTS

Physical properties

Texture :

These soils are only of one type, i.e. clayey, having a very large proportion of clay and silt and almost little amount of sand particles.

The maximum value 49.5 % of clay and 35.3 % of silt were found in site II and 20.5 % of sand was found in site III (Tab. I).

Properties	Site I	Site II	Site III
Textural class	Clay	Clay	Clay
Texture (%)			
Clay	49.32	49.47	47.33
Silt	31.38	35.32	32.08
Sand	19.28	15.05	20.49
Water holding capacity (%)	49.83	56.97	54.66
Bulk density (g/c.c)	1.39	1.32	1.41
Porosity (%)	47.54	50.18	46.79

Tab. I : Texture, water holding capacity, bulk density and porosity of soil on the three study sites.

Water holding capacity :

The water holding capacity varies from site to site and the values range between 49.8 % to 57.0 %. This maximum value was obtained in site II (Tab. I).

Bulk density and porosity :

The maximum values 1.4 g/c.c. of bulk density and 50.2 % of porosity were recorded in site III and II respectively (Tab. I).

Moisture content :

As data indicate (Tab. II), the moisture content dropped gradually from December to June in all three sites.

Chemical properties

Soil pH :

These soils are generally acidic with the exception of few saline and alkaline soil. There was no definite trend being found in pH values between different months and different sites. The pH values range between 6.9 to 7.5 for site I, 6.3 to 7.0 for site II and 6.4 to 7.1 for site III (Tab. II).

Month	Site	Moisture (%)	pH	Organic carbon (%)	Nitrogen (%)	C/N ratio	Available phosphorus (ppm)
December	I	16.63	6.9	1.62	0.17	9.52	292
	II	18.69	6.5	1.02	0.16	6.37	198
	III	13.33	6.8	0.98	0.14	7.00	178
January	I	12.98	7.2	1.57	0.15	10.46	281
	II	14.55	6.6	0.81	0.15	5.40	179
	III	9.75	6.5	0.89	0.11	8.09	158
February	I	10.20	7.5	1.79	0.16	11.19	251
	II	12.64	6.4	1.07	0.16	6.68	168
	III	8.06	6.9	1.26	0.15	8.40	159
March	I	5.85	6.9	1.35	0.13	10.38	242
	II	8.59	6.3	1.02	0.13	7.84	145
	III	6.34	7.1	1.32	0.17	7.76	168
April	I	4.95	6.9	1.39	0.15	9.26	252
	II	6.32	6.8	1.07	0.12	8.91	139
	III	4.63	6.7	1.29	0.15	8.60	177
May	I	3.99	7.0	1.45	0.12	12.08	273
	II	5.93	7.0	1.05	0.11	9.54	129
	III	4.45	6.7	0.95	0.10	9.50	179
June	I	3.35	7.2	1.38	0.09	15.33	249
	II	5.54	6.9	1.15	0.08	14.37	138
	III	3.22	6.4	0.87	0.09	9.66	158

Tab. II : Monthly variation in the moisture content, pH, organic carbon, nitrogen, C/N ratio and available phosphorus on the three study sites.

Organic carbon :

Organic carbon varied between 1.79 to 1.35 % for site I, 1.15 to 0.81 % for site II and 1.32 to 0.87 % for site III. Data of organic carbon did not show any definite pattern between different months and sites. Its highest values were obtained 1.79 %, 1.15 % and 1.32 % with respect to site I, II and III (Tab. II).

Nitrogen :

The maximum values of total organic nitrogen were estimated 0.17 %, 0.16 % and 0.17 % for site I, II and III respectively. Values range between 0.09 % to 0.17 % for site I, 0.08 % to 0.16 % for site II and 0.09 % to 0.17 % for site III. Values fluctuate in wet season, but a definite decreasing trend was recorded in the hot season (Tab. II).

C/N ratio :

C/N ratio range between 9.3 to 15.3 for site I, 5.4 to 14.4 for site II and 7.0 to 9.7 for site III. The highest value of C/N ratio was observed in the June in all three sites. The value exhibit a definite increasing trend from December to June on all three sites.

Available phosphorus :

The maximum value of phosphorus was estimated 292 ppm for site I, 198 ppm for site II and 179 ppm for site III. The available phosphorus of site I is comparatively higher than that of other two sites. The values of available phosphorus decreased gradually in hot season (Tab. II).

Exchangeable calcium :

The exchangeable calcium range between 5.45 to 8.05 m.e. % for site I, 3.35 to 5.51 m.e. % for site II, and 4.16 to 6.39 m.e. % for site III. The calcium content of study site I is comparatively higher than that of other two sites.

Exchangeable potassium :

Exchangeable potassium was obtained maximum in site II as compared to site I and III. Its value ranges between 0.937 to 1.638 m.e. % for site I, 1.543 to 2.383 m.e. % for site II and 1.345 to 1.901 m.e. % for site III (Tab. III).

Exchangeable sodium :

As indicated in the table III it is value was found in between 0.317 to 0.192 m.e. % for site I, 0.343 to 0.235 m.e. % for site II and 0.349 to 0.235 m.e. % for site III (Tab. III).

Total exchangeable cations :

High value of total exchangeable cations was found 22.05 m.e. % 17.95 m.e. % and 21.11 m.e. % with respect to site I, II and III. Its

maximum value was investigated in site I and then followed by site III and II (Tab. III).

Month	Site	Exchangeable cations (m.e. %)			
		Ca	K	Na	Total cations
December	I	8.051	1.325	0.294	21.33
	II	5.513	2.012	0.245	17.95
	III	6.321	1.730	0.256	21.11
January	I	7.983	1.433	0.274	21.69
	II	4.997	2.001	0.270	17.75
	III	5.932	1.345	0.349	19.54
February	I	7.593	1.541	0.254	21.55
	II	4.521	1.993	0.250	17.00
	III	6.226	1.560	0.235	20.12
March	I	6.483	1.633	0.317	20.66
	II	3.652	2.383	0.331	15.32
	III	5.593	1.440	0.272	19.35
April	I	6.932	0.937	0.305	19.49
	II	3.353	2.245	0.343	14.50
	III	6.386	1.640	0.309	18.00
May	I	7.030	1.557	0.287	22.05
	II	3.967	1.543	0.332	14.09
	III	4.362	1.651	0.232	16.32
June	I	5.453	1.205	0.192	20.31
	II	4.199	1.698	0.235	13.60
	III	4.161	1.901	0.294	15.09

Tab. III : Monthly variation in the exchangeable calcium, potassium, sodium and total exchangeable cations on the three study sites.

DISCUSSION

The pond soils are transported by rain water from surrounding upland area and collected in the pond during rainy season. The results indicate that the soils of all study sites are heavy, due to high pro-

portion of clay particles, and thus the soils are clayey. These soils give certain peculiar characteristics. Clay is well known for its property of absorbing water and swelling when placed in water but contracts very much on drying. Consequently when soils of these ponds dry up, they form very deep and wide craks. These cracks help in the aeration of the soils otherwise very compact. On account of clayey bottom these ponds are able to retain accumulated water above their surface for long time. These conditions have selected a typical flora. The presence of the following plants was observed : *Mollugo hirta*, *Polygonum plebejum*, *Heliotropium indicum*, *Gnaphalium indicum*, *G. luteo-album*, *G. pulvinatum*, *Grangea maderaspatana*, *Sphaeranthus indicus*, *Coldenia procumbens*, *Crozophora rottleri*, *Ludwigia parviflora*, *Lippia nodiflora*. Such plants are able to survive for longer time in summer as compared to plants growing on other types of soils.

As table II indicate the moisture content decreased gradually from December to June and it is due to evaporation of water from pond with respect to summer months and also transpiration by plants already growing on them.

The soils are generally acidic due to formation of organic acid from the decomposition of plant residues.

As results indicate (Tab. III), the pond soils are rich in organic carbon, nitrogen and C/N ratio as compared to surrounding upland area and this is mainly due to the presence of plant residues of rainy season and humus in more quantity. Due to high amount of humus organic carbon is also high. In the soil it is the content of carbon which determines the extent of biological activity and the relative release of nitrogen and phosphorus for the use of micro-organisms in the soils and of growing plants. In the moist season the rate of decomposition is quite high as compared to hot season and therefore relative release of nitrogen and phosphorus increased in the wet season and decrease in the hot season.

It has been shown by many workers that the soils organic matter generally increases the soil aggregation and improves the soil texture, thereby promoting better plant growth (AKERMAN & MYERS, 1953; MARTIN, 1942; KOLODNY & NEAL, 1941). It also improved the water holding capacity due to adequate amount of humus in the soil.

These soils by virtue of their situation at lower level, rich in clay content and water logging for long periods accompanied by poor

drainage, result in less leaching, producing higher base status. Thus, even the minimum values of these exchangeable cations, i.e. calcium, potassium, sodium and total exchangeable cations, are high as compared to those of surrounding upland drained soils, as reported by RAMAM (1966).

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REFERENCES

AKERMAN, F.G. & MYERS, H.E., 1943. Some factors influencing aggregation of clay pan soils. *Soil Sci.*, 55, 405-413.

BARCLAY, M., 1966. An ecological study of a temporary pond near Aukland, *New Zealand. Aust. J. Mar. Freshwater Res.*, 17, 239.

JACKSON, M.L., 1958. *Soil chemical analysis.* Prentice-Hall., Eglewood Cliffs, 82-204.

KOLODNY, L. & NEAL, O.R., 1941. The use of micro-aggregation or disperson measurements for flowering changes in soil structure. *Proc. Soil. Sci. Soc. Amer.*, 6, 91-95.

MARTIN, J.P., 1942. The effect of compost and compost materials upon the aggregation of the silt and clay particles of Collington sandy loam. *Proc. Soil. Sci. Soc. Amer.*, 7, 218-222.

MALL, L.P., 1953. Ecology of drying ponds and some common weeds. Ph. D. thesis, Saugar Univ., Sagar, 148 p.

MISRA, R., 1946. A study in the ecology of low-lying lands. *Indian Ecologist*, 1, 1-20.

PIPER, C.S., 1966. *Soil and plant analysis.* Hans. Publishers, Bombay, 229 p.

RATNAM, B.V. & JOSHI, M.C., 1952. An ecological study of the vegetation near about a temporary pond in Pilani. *Proc. Raj. Acad. Sci.*, 3, 1-15.

RAMAM, S.S., 1966. Organisation of grass communities on western and Vindhyan Uplands of Varanasi District. *Jour. Ind. Bot. Soc.*, 14 (3 & 4), 266-276.