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# PHOSPHATE STATUS OF SOME SUB-HUMID TROPICAL SOILS OF BANGLADESH

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**Abstract**

Amounts of total, inorganic, organic and inositol phosphates varied significantly and ranged from 242 to 620, 143 to 404, 63 to 307 and 36 to 188 ppm with an average of 436, 263, 169 and 86 ppm, respectively. Inorganic and organic phosphates accounted for 49 to 81 per cent and 19 to 51 per cent of total phosphates, respectively. Inositol phosphate constituted about 42 to 66 per cent of organic phosphates.

Correlation studies suggested that significant variation in total, inorganic and organic phosphates were related to clay, organic carbon and total nitrogen contents of the soils. However, the most influencing variable was the clay content for their variation in soils. Organic carbon was also significantly responsible for the accumulation of organic phosphate. Inositol phosphate was directly and significantly associated with the amount of soil organic phosphates and clay contents. In contrast, pH showed no significant contribution for the accumulation of any form of phosphate in the soil. However, multiple correlations ascertained that all these properties contributed together for any change in the level of phosphate fractions in soil.

## Introduction

The estimation of the amount of different forms of phosphate is pratically important because the surface soils contain highest concentrations and the roots of common agricultural crops derive their phosphate from this region (Gupta and Singh, 1972; Bahan and Shanker, 1973). In view of this fact Parker (1953) stated that "the total phosphate content is the only avilable basis on which the phosphate fertility of a large number of soils can be evaluated and that it serves as an index of phosphate reserves". Moreover, inorganic phosphate having a great residual value to phosphate fertility constitutes the greatest proportion of total phosphate in soil (Pierre, 1948). Furthermore, the significance of organic phosphate cannot be overlooked since it comprises a significant fraction of total phosphate and also plays a vital role in plant nutrition through its steady supply via mineralization (Cosgrove, 1967). Nevertheless, the significant contribution of inositol phoshate in soil-plant phosphate cycle deserves considerable degree of attention too (Anderson, 1967).

A large volume of work has been done for soils developed under temperate climate. However, only a little information is available on this aspect for humid and sub-humid tropical soils. Thus, this investigation was carried out with a view to assessing the various fractions of phosphate in some sub-humid tropical soils of Bangladesh.

## Materials and Method

Soil samples (0-15 cm) were collected from sixteen representative series of the districts of Dhaka, Comilla, Chittagong, Noakhali, Feni, Narshingdi, Khulna, Tangail and Dinajpur. The samples were air dried. ground and passed through 2 mm sieve for mechanical analysis and through 0.5 mm sieve for chemical analysis.

Mechanical analysis was done by hydrometer method and that of textural class was determined from USDA triangular cordinate system. pH was measured electrochemically by using Corning glass electrode pH meter (Model-7) from a soil suspension (soil:water=1:2.5) and that of CEC from 1N neutral $NH_4OAc$ extract. Organic carbon was estimated volumetrically by wet oxidation method (Walkley and Black, 1934) and total nitrogen was determined by Kjeldahl procedure, described by Jackson (1962). The physical and chemical properties of the soils are presented in Table 1.

Total, inorganic and organic phosphates were estimated by following the method outlined by Mehta *et al.* (1954). Procedure devised by Mc Kercher and Anderson (1968) was used to determine the inositol phosphate contents of the soils.

## Results and Discussion

Values for total, inorganic, organic and inositol phosphates are presented in Table 2.

(a) *Total phosphate contents*: Total phosphate contents of the soils varied significantly ranging from 242 to 620 ppm with an average of 436 ppm, the minimum and the maximum amounts have been observed in Jhalkathi and Naraibag series, respectively. Studies by Karim and Khan (1956), Islam and Chowdhury (1966) and Islam *et al.* (1981) revealed that Bangladesh soils are generally low in total phosphate and their values ranging from 201 (Amnura series) to 850 ppm (Harta series) are of high degree of agreement with those obtained in this study. The values are again satisfactorily comparable with those reported for the soils of USA (Prince *et al.*, 1948), New Guinea (Hardon, 1936), Ghana (Nye and Bertheux, 1957), Central Asia (Chumachenke, 1959), Nigeria (Enwezor and Moore, 1966), USSR (Valasyuk *et al.*, 1974) and India (Kanwar and Grewal, 1959; Dhua and Joshi, 1972 and Gupta and Singh, 1972).

**Table 1. Some physical and chemical properties of the soil samples.**

| Soil series | Texture* | % Caly | pH | CEC (meq/100g) | % O.C. | % total N |
|---|---|---|---|---|---|---|
| Hatiya | SiCL | 29 | 7.1 | 24.4 | 0.72 | 0.04 |
| Ramgati | SiCL | 34 | 7.8 | 22.1 | 0.53 | 0.04 |
| Savar Bazar | SiC | 48 | 5.3 | 20.5 | 1.02 | 0.07 |
| Sonatala | SiL | 24 | 5.3 | 15.5 | 0.46 | 0.05 |
| Jhalkathi | SiL | 21 | 7.7 | 20.2 | 0.32 | 0.03 |
| Pahartali | CL | 34 | 6.0 | 10.6 | 0.82 | 0.07 |
| Chakla | C | 46 | 5.5 | 27.4 | 0.60 | 0.07 |
| Naraibag | C | 63 | 5.5 | 29.6 | 0.85 | 0.06 |
| Jalkundi | SiL | 24 | 5.8 | 23.1 | 0.71 | 0.07 |
| Ghatail | SiCL | 36 | 6.3 | 15.5 | 0.84 | 0.06 |
| Pachagarh | SCL | 26 | 5.4 | 25.3 | 0.36 | 0.03 |
| Gerua | SiCL | 33 | 4.5 | 16.3 | 0.76 | 0.06 |
| Salna | SiL | 26 | 5.0 | 13.1 | 0.59 | 0.03 |
| Tejgaon | L | 23 | 5.4 | 12.2 | 0.71 | 0.05 |
| Noadda | CL | 39 | 5.1 | 14.7 | 0.82 | 0.05 |
| Chandra | CL | 31 | 4.8 | 14.0 | 0.62 | 0.03 |

* Texture : S= Sand ; Si= Silt ; C= Clay and L= Loam

Based on Parker's (1953) classification the soils under present investigation could be classified into two categories, namely "medium" (0.021 to 0.043 per cent) and "high" (0.043 to 0.083 per cent) in total phosphates. Hatiya, Sonatala, Jhalkathi, Jalkundi, Pachagarh, Salna, Tejgan and Chandra series are "medium" in total phosphate content and the rest of the series belongs to the category "high" in total phosphate. However, Islam (1960) observed that Bangladesh soils on an average contained 0.043 per cent total phosphate and he proposed that "this value is to be the standard for Bangladesh soils, against which the analytical data for individual soil samples are to be compared, and to decide whether a soil would be deficient or sufficient in phosphate". On this basis, the soils under present study fall into the following categories :

(1) Deficient : Sonatala, Jhalkathi, Jalkundi, Pachagarh, Salna, Tejgaon and Chandra.

(2) Optimum : Hatiya and Pahartalli.

(3) Sufficient : Ramgati, Savar Bazar, Chakla, Naraibag, Ghatail, Gerua and Noadda.

Correlation studies showed that the content of total phosphates increased significantly with an increase in clay, total nitrogen and organic carbon contents

**Table 2. Phosphate contents of the soil samples.**

| Soil series | Total P | Inorganic P | | Organic P | | Inositol P | |
|---|---|---|---|---|---|---|---|
| | ppm | ppm | Per cent* | ppm | Per cent* | ppm | Per cent** |
| Hatiya | 426 | 295 | 69 | 131 | 31 | 60 | 46 |
| Ramgati | 543 | 321 | 59 | 222 | 41 | 106 | 48 |
| Savar Bazar | 610 | 404 | 66 | 207 | 34 | 112 | 54 |
| Sonatala | 293 | 196 | 67 | 97 | 33 | 41 | 42 |
| Jalkundi | 360 | 282 | 78 | 78 | 22 | 36 | 46 |
| Jhalkathi | 242 | 143 | 59 | 99 | 41 | 45 | 45 |
| Pahartali | 491 | 302 | 62 | 189 | 38 | 98 | 52 |
| Chakla | 597 | 291 | 49 | 307 | 51 | 188 | 61 |
| Naraibag | 620 | 325 | 52 | 295 | 48 | 123 | 42 |
| Ghatail | 540 | 302 | 56 | 238 | 44 | 119 | 50 |
| Pachagarh | 280 | 161 | 57 | 120 | 43 | 79 | 66 |
| Gerua | 510 | 296 | 58 | 215 | 42 | 102 | 48 |
| Salna | 321 | 203 | 63 | 118 | 37 | 75 | 64 |
| Tejgaon | 285 | 198 | 69 | 87 | 31 | 42 | 48 |
| Noadda | 527 | 290 | 55 | 237 | 45 | 123 | 52 |
| Chandra | 325 | 263 | 81 | 63 | 19 | 37 | 58 |
| s.e. | ±2.88 | ±2.07 | ±2.07 | ±2.22 | ±0.74 | ±1.63 | ±0.68 |

* Per cent of total phosphates ; ** Per cent of organic phosphates.

of the soils (Table 3). The most influencing factor causing variation was the clay content. Williams and Sanders (1956) and Mc Donnel and Walsh (1957) demonstrated that most of the organic and inorganic phosphates were associated with the clay contents. Similar results were reported by other investigators also (Nye and Bertheux, 1957; Goel and Agarwal, 1960; Bates and Baker, 1960 and Islam and Ahmed, 1973).

The importance of clay was more justified when all possible correlation coefficients were considered (Table 3). The combination of factors, where clay content was included, showed better correlations than those without clay. For

**Table 3. Simple, partial and multiple correlation coefficients (r) between phosphate fractions and soil properties.**

| Soil properties * | Correlation coefficient (r) | | | |
|---|---|---|---|---|
| | Total P | Inorganic P | Organic P | Inositol P |
| X1 | 0.8590 | 0.7103 | 0.8281 | 0.7429 |
| X2 | 0.7123 | 0.8342 | 0.4731 | 0.3863 |
| X3 | 0.5624 | 0.5919 | 0.4318 | 0.4046 |
| X4 | −0.0297 | 0.0504 | −0.0062 | −0.0843 |
| X5 | — — — | 0.8845 | 0.9138 | 0.9495 |
| X1.X2 | 0.8909 | 0.8718 | 0.8292 | 0.7478 |
| X1.X3 | 0.8817 | 0.7756 | 0.8305 | 0.7468 |
| X1.X4 | 0.8704 | 0.7159 | 0.8431 | 0.7454 |
| X1.X5 | — — — | 0.8898 | 0.9177 | 0.9527 |
| X2.X3 | 0.7241 | 0.8363 | 0.5020 | 0.4394 |
| X2.X4 | 0.7419 | 0.8644 | 0.4969 | 0.3884 |
| X2.X5 | — — — | 0.9318 | 0.9483 | 0.9523 |
| X3.X4 | 0.5893 | 0.6165 | 0.4561 | 0.4161 |
| X3.X5 | — — — | 0.8925 | 0.9196 | 0.9496 |
| X4.X5 | — — — | 0.8849 | 0.9140 | 0.9528 |
| X1.X2.X3 | 0.8945 | 0.8725 | 0.8357 | 0.7627 |
| X1.X2.X4 | 0.9142 | 0.9007 | 0.8431 | 0.7489 |
| X1.X2.X5 | — — — | 0.9362 | 0.9520 | 0.9536 |
| X1.X3.X4 | 0.8993 | 0.7892 | 0.8481 | 0.7506 |
| X1.X3.X5 | — — — | 0.8969 | 0.9229 | 0.9529 |
| X1.X4.X5 | — — — | 0.8918 | 0.9191 | 0.9592 |
| X2.X3.X4 | 0.7545 | 0.8669 | 0.5263 | 0.4420 |
| X2.X3.X5 | — — — | 0.9314 | 0.9484 | 0.9533 |
| X2.X4.X5 | — — — | 0.9375 | 0.9530 | 0.9587 |
| X3.X4.X5 | — — — | 0.8925 | 0.9196 | 0.9532 |
| X1.X2.X3.X4 | 0.9190 | 0.9017 | 0.8503 | 0.7642 |
| X1.X2.X3.X5 | — — — | 0.9365 | 0.9522 | 0.9545 |
| X1.X2.X4.X5 | — — — | 0.9395 | 0.9545 | 0.9618 |
| X1.X3.X4.X5 | — — — | 0.8973 | 0.9231 | 0.9593 |
| X2.X3.X4.X5 | — — — | 0.9376 | 0.9530 | 0.9594 |
| X1.X2.X3.X4.X5 | — — — | 0.9396 | 0.9546 | 0.9622 |

* X1 = Clay, X2 = Organic carbon, X3 = Total N, X4 = pH,
X5 = Total P for inorganic P and organic P, and organic P for inositol P.

Level of significance : P 0.1 = 0.4259, P 0.05 = 0.4973, P 0.02 = 0.5742,
P 0.01 = 0.6226 and P 0.001 = 0.7420.

example, the value of r was 0.7545 when organic carbon, total nitrogen and pH were included together. But when clay content of the soils was included along with these factors, the value of r increased and became 0.9190. This possibly explain the significance of clay in the variation of total phosphates in soil.

However, a better relation from multiple correlation suggested that clay, organic carbon, total nitrogen and pH contributed together for the variation of total phosphates in soil (Table 3).

(b) *Inorganic phosphate contents*: A significant variation in inorganic phosphate contents of the soils was observed (Table 2). Values for the same varied between 143 and 404 ppm with an overall mean of 263 ppm. The highest and the lowest values were recorded in Savar Bazar and Jhalkathi series, respectively. The values agreed fairly well with those reported by Islam and Khan (1967) and Islam and Ahmed (1973). Inorganic phosphate content of Bangladesh soils was found to range from 102 (Amnura series) to 603 ppm (Rangpur sandy loam) in the previous investigations. Comparable values were also reported for some soils of other countries *viz*. 309 ppm in El-Salvador (William *et al.*, 1964), 220 ppm in United Kingdom (Hanley, 1965), 215 ppm in Nigeria (Enwezor and Moore, 1966) and 265 ppm in the soils of Ceylone (Pavanasasivam and Kalpage, 1970).

The variation of inorganic phosphates was found to be significantly related to total nitrogen, total phosphates, clay and organic carbon contents of the soils (Table 3). Non-significant and negative relationship was recorded with soil pH. Variation in inorganic phosphates with these soil properties was also proposed by other workers (Nye and Bertheux, 1957 and Bates and Baker, 1960).

A partial correlation indicated that apart from total phosphates two other properties namely, organic carbon and clay content of soils are responsible for the variation of inorganic phosphate contents. However, a multiple correlation (Table 3) suggested that all these soils properties are involved for any change in inorganic phosphate level in the soil.

(c) *Organic phosphate contents*: Significantly variable quantities of organic phosphate was found in the soils (Table 2). Amounts of organic phosphate varied between 63 (Chandra series) and 307 ppm (Chakla series) with an average value of 169 ppm. This fraction comprised of about 19 to 51 per cent of the total phosphates. The results agreed favourably with the reported values ranging from 14 to 75, 27 to 67, 46 to 69, 38 to 70, 31 to 72, 21 to 74 and 12 to 56 per cent of total phosphates in some soils of India (Ghani and Aleem, 1943), Scotland (Williams and Sanders, 1956), Ghana (Acquaye, 1963), Ierland ( Hanley, 1965 ), Nigeria ( Enwezor and Moore, 1966 ), Southern Nigeria (Omotoso, 1971) and of Bangladesh (Ahmed and Islam, 1971 and Islam *et al.*, 1981), respectively.

Organic phosphates showed significant relationship with total phosphates, clay, organic carbon and total nitrogen content of soils (Table 3). No significant role of pH was observed for the variation of this fraction of phosphate in the soil. Soil organic matter contains a fairly uniform proportion of organic phosphate (Anderson, 1967) and a highly significant correlation generally exists between them (Nye and Bertheux, 1957; Goel and Agarwal, 1960 and Acquaye, 1963). But, in the present investigation the relationship was found to be significant only at 10 per cent level. However, it could be supported by Mc Donnel and Walsh (1957) who commented, "while for each individual soil there is a parallel between organic matter and organic phosphates, the relationship between different soils is not so straight forward". The dependence of organic phosphate level on soil nitrogen was demonstrated by Pearson *et al.* (1940), Thompson *et al.* (1954) and John *et al.* (1965).

From the consideration of partial correlation, variation in organic phosphates was found to be related mainly with total phosphates followed by clay content of the soils (Table 3). However, multiple correlation revealed that all the soil variables included in the study was jointly responsible for such variation.

(*d*) *Inositol phosphate contents* : Contents of inositol phosphate varied significautly from soil to soil and ranged from 35 to 188 ppm with an average of 86 ppm (Table 2). Maximum and minimum values were observed in Chakla and Jalkundi series, respectively. The fraction constituted about 42 to 66 per cent of organic phosphates. Anderson (1967) stated that inositol phosphate, among the components of soil organic phosphate, constitutes the major proportion of orgnic phosphates in the soil. These values are in good agreement with the reported findings of 67 to 83 per cent of organic phophate in Iowan soils (Smith and Clark, 1951), 25 to 90 per cent in New York soils (Alexander, 1961) and 9 to 83 per cent in Bangladesh soils (Ahmed and Islam, 1971).

Inositol phosphate showed significant relationship with only clay and organic phosphate contents of soils (Table 3). Partial correlation suggested that organic phosphates explain most of the variations of inositol phosphate in soil. However, multiple correlation revealed that all the variables were responsible combinedly for the variation of inositol phosphate.

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