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Assessment of soil quality in relationship with aluminium phosphide (ALP) and rotenone in selected fish ponds of Rajshahi district in Bangladesh

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Abstract
The aim of this research was to assess the soil quality parameters in relationship with two fish killer chemicals, aluminium phosphide (AlP) and rotenone in some selected fish ponds at Taherpur Municipality under Bagmara Upazila of Rajshahi District in Bangladesh from July 2018 to December 2018. AlP and rotenone are frequently used in the water of the study area to remove all kinds of fish species to prepare a pond before start-up. At this time, a total of 10 different soil quality parameters *viz*., pH, organic matter (OM), total nitrogen (TN), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), sulfur (S), zinc (Zn) and iron (Fe) were examined against the fish killer chemical with control. Analyzing the results obtained, only mean values of pH (7.22±0.31) and Mg (1.46±0.18 meq/100 g) were increased in case of application of AlP compared to the control, and the mean values of the other eight properties were decreased. The mean values of pH, OM, TN, K, Ca, Mg, P, S, Zn and Fe were 7.02±033, 1.27±0.13, 0.07±0.01%, 1.05±0.22 meq/100 g, 7.70±0.54 meq/100 g, 1.64±0.17 meq/100 g, 55.89±4.89 µg/g, 127.44±26.15 µg/g, 1.66±0.32 µg/g and 135.96±9.67 µg/g respectively after rotenone application which were higher than control values except for TN. These results suggested that the application of rotenone was suitable for use in fish ponds instead of the AlP. One-way analysis of variance (ANOVA) revealed that only potassium and iron showed significant differences in respect of control and treatments (AlP and rotenone) at the level of $p<0.01$ and $p<0.05$ respectively. According to Pearson correlation (r^2) values, the strong positive correlation was exposed the relationships between control and AlP such as S (r = 0.988), K (r = 0.986), Fe (r = 0.969), pH (r = 0.951), Mg (r = 0.883), Zn (r = 0.839) and P (r = 0.839). On the other hand, K (r = 0.999), S (r = 0.996), P (r = 0.967), Fe (r = 0.963), pH (r = 0.959), Zn (r = 0.869), TN (r = 0.848), Mg (r = 0.846) and OM (r = 0.813) showed the highly positive relationships between control and rotenone. The present investigation proposes future research on effects on the fish production and the total environmental impacts of ponds as well as surrounding areas concerning AlP and rotenone.

Keywords: Soil quality parameters, fish killer chemicals, aluminium phosphide (AlP), rotenone, fish ponds, pH, organic matter

1. Introduction
The economic condition of Bangladesh is largely dependent on agriculture. Of the total GDP of Bangladesh, agricultural GDP is 11.52 percent, of which sub-sector fishing make-up 2.57 percent of Bangladesh's GDP [1].Fish culture is one of the most important occupations in our country; more than 12% of the population is directly or indirectly involved in this sector [2].The total pond area in Bangladesh was 404,497 hectares and production of 2,046,258 metric tons in which Rajshahi district covers 12,503 hectares that produce 62,703 metric tons of the total fish production [3]. Rajshahi district also contributes 3.09% of the total area of ponds in the country which contributes 3.06% of the total production [3]. On the other hand, fish and fisheries products subsidize 1.39 percent of total export earnings in our country [4].
The important elements of an ideal pond are the quality of the water and soil, condition of the weather of the area with their surrounding environments. It is generally shown that there is a great relationship between the water, soil, other organisms and fish, and when their balance is disturbed, imposes stress on the fish production [5]. Pond conditions are controlled by both natural factors and human impacts, and consequently the common natural factors such as the

source of the pond water and the types of soil at the bottom of the pond influence some water characteristics [6]. The natural condition and nutrient properties of the bottom soil are considered to be highly influencing factors for the productivity of pond aquaculture and perform as a ground for the growth of algal Pasteur as well as control pond bottom stability [7-8]. The soil also provides shelter and food for bottom-dwelling animals and performances as a "storehouse of nutrients" for aquacultures [9].

It is reported that pH, organic matter concentration, nitrogen, and phosphorus in soils were very important elements for fish production in ponds [10]. The physio-chemical properties of soil are very important to increasing fish productivity and preventing various fish diseases [11]. One of the vital physical components of the soil is the pH, and its optimal range is from 6.5 to 9 [12]. The increase of pH in the soil will cause the fish floating in the pond and even die, and a decrease in the pH will impede the growth of the fish [13]. It is reported that when the pH level in the water rises, oxygen levels usually decrease and the shortage of oxygen or excess of it may affect fish production [14]. The chemical properties of soil such as organic matter (OM), total nitrogen (TN), potassium(K), calcium (Ca), Magnesium (Mg), phosphorus(P), sulfur(S), zinc (Zn) and iron (Fe) have strong associations with the water quality of ponds as well as fish production [15]. It has been reported that the concentration of organic meter is lower in new ponds and increasing the pond's age simultaneously decreases these organic matters in the bottom soil [16-18]. A previous study has revealed that the degradation of organic matter reduces the biological productivity of the soils [19]. Numerous authors have confirmed that the optimal range of soil pH, nitrogen, potassium, phosphorus, carbon as well as other chemical composition of soil has associated to influence pond productivity and fish production [20-24].

Several scientists reported that the characteristics and condition of bottom soil are very much essential in pond management and the decreasing of the elements of soil limiting fish production in ponds day by day [5, 8]. It is also reported that our fish farmers use different types of fish feed, fertilizers, insecticides, probiotics, calcium and vitamins in the fish ponds, but they do not know about the adverse effects of these [25]. Specially, in Bangladesh, the fish killer chemicals, aluminium phosphide (AlP) and rotenone are normally used in water to twitch a new pond for eliminating all kinds of fish species before restocking. Some research has been conducted on pond soils; however, the effects of AlP and rotenone on the bottom soil in ponds remain unknown. In order to find out these problems, the present research was intended to the assessment of bottom soil quality parameters in relationship with aluminium phosphide (AlP) and rotenone in some selected fish ponds at Taherpur Municipality under Bagmara Upazila, Rajshahi District of the northwest region of Bangladesh.

2. Materials and Methods

2.1. Study area

The study was conducted in one of the major fish production areas at Taherpur Municipality in Bagmara Upazila under the Rajshahi District which is an area of the North-western part of Bangladesh (Fig 1). The total area of Taherpur Municipality is 363.3 sq km; situated between 24°30' and 24°41' north latitudes and between 88°41' and 88°58' east longitudes. This municipality is restricted by Manda and Atrai Upazila on the north; Durgapur, Puthia and Natore Sadar Upazila on the east and Mohonpur Upazila on the west. It is 30 km distant from Rajshahi city and 10 km remote from Baghmara Upazila.

2.2. Sampling ponds

Three different sampling ponds were selected, and three replications were maintained for the collection of soil samples every time from each pond (Fig 2). Out of a total of 27 soil samples, nine were aluminium phosphide (AlP), nine were rotenone and nine were controls. The total area of the three ponds was 115.5 decimal (3.5 bigha). The sample were collected from July 2018 to December 2018.

2.3. Sample preparation

AlP and rotenone were used throughout the experiments as fish killer chemicals. The fishermen and the present research applied the dose for AlP at 330 tablets/ 1 bigha/ 5 feet water depth. For the rotenone, 2 kg/ 1 bigha/ 5 feet water depth was used to keep the similarity with the fish farmers. After collection of soil, samples were dried at room temperature and then mixed with a manual mixer. It is immediately transferred in plastic jars.

2.4. Determination of physio-chemical parameters

Physical data were collected on ten parameters *viz*., pH, organic matter (OM), total nitrogen (TN), potassium (K), calcium (Ca), Magnesium (Mg), phosphorus (P), sulfur (S), zinc (Zn) and iron (Fe). The controls were maintained with respect to AlP and rotenone. Then soil samples were carried out to the Soil Resource Development Institute, Rajshahi regional office.

2.5. Statistical analysis

All data were calculated using Microsoft Office Excel (version 2019). Descriptive statistics, one-way analysis of variance (ANOVA), and Pearson's correlation were executed. $p<0.05$ (*) was considered statistically significant.

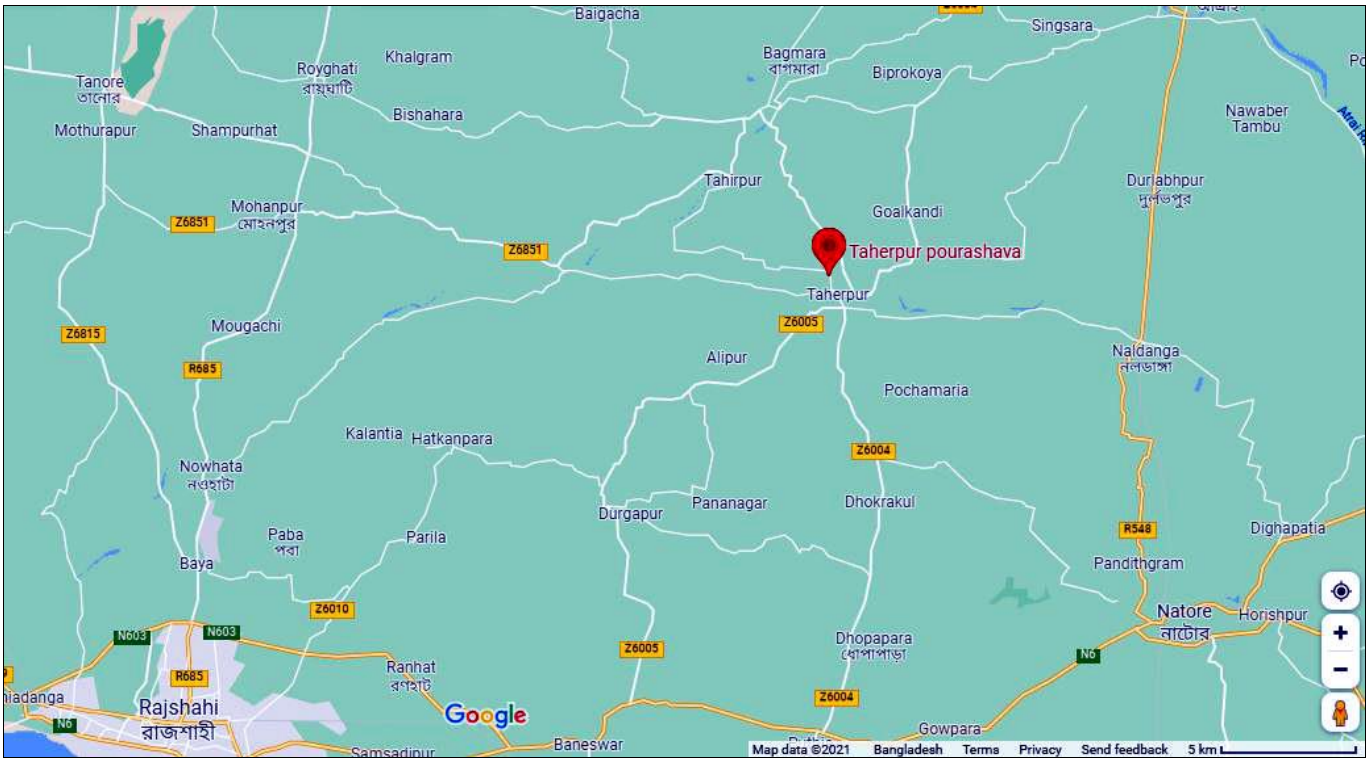

Fig 1: Map of study area at Taherpur Municipality (Pourashava).

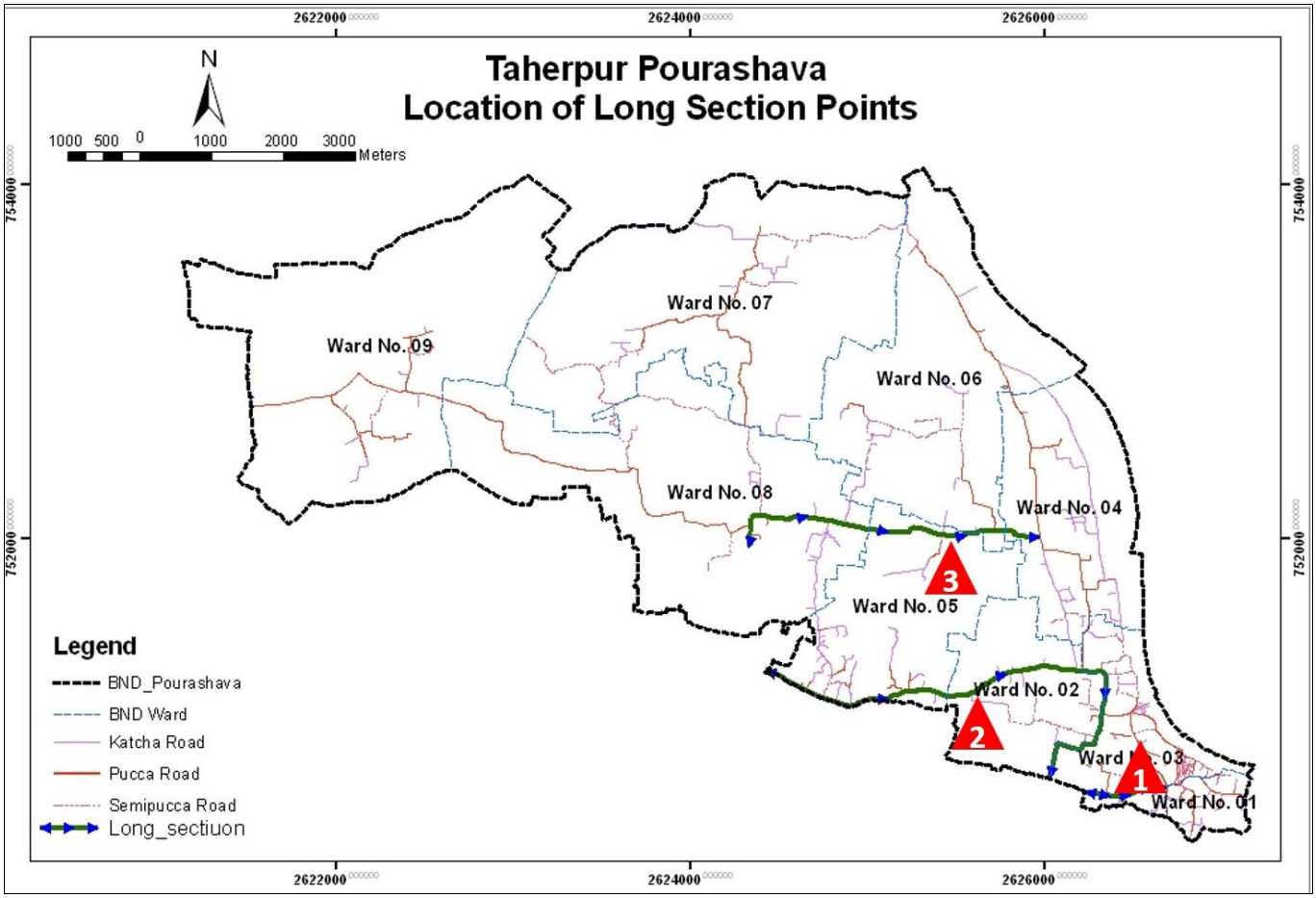

Fig 2: Map of sampling ponds at Taherpur Municipality (Pourashava). Triangles show the pond location.

3. Results and Discussion

3.1. Status of the soil properties

The highest pH value of the soil was recorded at 7.57±0.06 and the lowest value was 6.97±0.84 for AlP (Table 1). For rotenone, the maximum value of pH of the soil was recorded at 7.40±0.10 and the minimum value was 6.80±0.69 (Table 2). The mean value was documented against ALP and rotenone as 7.22±0.31 and 7.02±0.33 respectively (Table 1, 2). The pH is an essential parameter because it significantly affects the soil quality [10]. Our result indicates that the soil of

the pond is slightly alkaline in nature. The acceptable range of pH for fish culture is 6.5 to 8.5 according to Bangladesh standards, FAO standards and Bangladesh Environment Conservation Rule [26, 27]. More or less similar findings were observed by Bhuiyan *et al.* [28] in a fish pond in Rajshahi, Bangladesh.

The highest value of the organic matter (OM) in soil was recorded at 0.92±0.37% and the lowest value was 0.88±0.62% for AlP (Table 1). For rotenone, the maximum value of Organic matter in soil was recorded at 1.39±0.20% and the minimum value was 1.13±0.45% (Table 2). The mean value was documented against AlP and rotenone as 0.89±0.03 and 1.27±0.13% respectively (Table 1, 2). A similar result showed that the range of organic matter was between 0.2 and 2.1% [29]. It is proposed that the satisfactory level of soil organic matter is more than 1.29 [30]. In Lokdeo, Tarakanda, Silmondi and Melandah soil series the OM content ranged from (0.33 to 1.49%), (0.89 to 2.02%), (0.31 to 1.15%) and (0.35 to 1.41%), respectively [31].

The highest value of total nitrogen (N) of soil was recorded at 0.07±0.01% and the lowest value was 0.05±0.02% for AlP (Table 1). For rotenone, the maximum value of total N of soil was recorded at 0.08±0.01% and the minimum value was 0.07±0.02% (Table 2). The mean value was documented against AlP and rotenone as 0.06±0.01 and 0.07±0.01% respectively (Table 1, 2). These outcomes were very close to the findings of Portach and Islam [32] and SRDI [33]. It is also reported that the percentage of total N content in soil ranged from (0.034 to 0.11%), (0.053 to 0.15%), (0.021 to 0.074%) and (0.042 to 0.084%) in Lokdeo, Tarakanda, Silmondi and Melandah respectively [31].

The highest value of potassium (K) of soil was recorded at 0.63±0.01 meq/100 g and the lowest value was 0.44±0.24 meq/100 g for AlP (Table 1). For rotenone, the maximum value of K of soil was recorded at1.30±0.01 meq/100 g and the minimum value was 0.91±0.63 meq/100 g (Table 2). The mean value was documented against AlP and rotenone as 0.51±0.11 and 1.05±0.22 meq/100 g respectively (Table 1, 2). Potassium plays a vital role in photosynthesis, protein synthesis, starch formation and the translocation of crops, and continuous cropping decreases the content of available K in soil [34]. This result is somewhat consistent with the previous report that the concentration of potassium in four soil samples ranged from 0.15 (±0.05) to 0.75 (± 0,15) meq/100 g [35]. Our results show that potassium levels are higher for rotenone compared to this paper; it might be owing to the excess use of potassium fertilizer in the pond for more production [36].

Liming materials such as calcium carbonate (CaCO3) are often used to fish ponds worldwide to keep a satisfactory concentration of total alkalinity in water and neutralize bottom soil acidity [37]. In the present experiment, the highest value of calcium (Ca) in soil was recorded at 7.06±1.52 meq/100 g and the lowest value was 6.77±0.52 meq/100 g for AlP (Table 1). For rotenone, the maximum value of Ca in soil was recorded at 8.04±1.07 meq/100 g and the minimum value was 7.08±0.77 meq/100 g (Table 2). The mean value was documented against AlP and rotenone as 6.87±0.16 and 7.70±0.54 meq/100 g respectively (Table 1, 2). Similar results were found by Kumar *et al.* [35]. The results of the present study received support from the experiment done on the effect of calcium on neutralizing capacity of water and fish production conducted by Hartman *et al.* [38].

The highest value of magnesium (Mg) in soil was recorded at 1.60±0.34 meq/100 g and the lowest value was 1.26±0.05 meq/100 g for AlP (Table 1). For rotenone, the maximum value of Mg of soil was recorded at 1.76±0.39 meq/100 g and the minimum value was 1.45±0.16 meq/100 g (Table 2). The mean value was documented against AlP and rotenone as 1.46±0.18 and 1.64±0.17 meq/100 g respectively (Table 1, 2). The outcome agrees with the earlier result of Mg status ranging from 0.50 to 3.50 meq/100 g in soil [35].

Phosphorus (P) is a major element that controls the growth of all algae and plants in fish ponds [39]. In the present study, the highest value of P in soil was recorded at 52.60±1.25 µg/g and the lowest value was 47.03±12.87 µg/g for AlP (Table 1). For rotenone, the maximum value of P of soil was recorded at 61.53±0.67 µg/g and the minimum value was 52.93±13.73 µg/g (Table2). The mean value was documented against AlP and rotenone as 50.29±2.90 and 55.89±4.89 µg/g respectively (Table 1, 2). The status of P content revealed in this study is much higher than to experiment conducted by Tapader *et al.* [40], which showed the average content value was 3.84 ± 1.77 µg g^{-1}. Kumar *et al.* [35] showed the maximum value of P at 11.06 µg/g, which is also much lower than this study. The higher phosphorus values in the present study may be due to the fact that previous researchers [35, 40] used agricultural soils, whereas bottom soils of ponds were taken in this study where phosphorus was applied several times in a month.

The highest value of sulfur (S) in soil was recorded at 123.87±4.86 µg/g and the lowest value was 86.50±56.76 µg/g for AlP (Table 1). For rotenone, the maximum value of S of soil was recorded at 157.63±6.29 µg/g and the minimum value was 112.10±80.90 µg/g (Table 2). The mean value was documented against AlP and rotenone as 99.32±21.26 and 127.44±26.15 µg/g respectively (Table 1, 2). It is reported that the optimum S (22.51 µg g-1) status in the soil is suitable for crop production [35]. A previous study also found that the values of S were reached from 40.48 ± 8.17 to 541.91 ± 98.30 µg g-1 in experimental ponds [40].

The highest value of Zinc (Zn) in soil was recorded at 1.68±0.01 µg/g and the lowest value was 1.29±0.63 µg/g for AlP (Table 1). For rotenone, the maximum value of Zn of soil was recorded at 2.03±0.05 µg/g and the minimum value was 1.45±0.93 µg/g (Table 2). The mean value was documented against AlP and rotenone as 1.46±0.20 and 1.66±0.32 µg/g respectively (Table 1, 2). Shahid *et al.* [41] and Kumar *et al.* [35] reported on S content in the soil which was more or less similar to this study. Another study found that large applications of P fertilizers may have an advantageous effect on Zn toxicity [42].

The highest value of iron (Fe) in soil was recorded at 124.79±19.54 µg/g and the lowest value was 110.76±0.66 for AlP µg/g (Table 1). For rotenone, the maximum value of Fe in soil was recorded at 143.83±27.69 µg/g and the minimum value was 125.17±0.60 µg/g (Table 2). The mean value was documented against AlP and rotenone as 119.59±7.69 and 135.96±9.67 µg/g respectively (Table 1, 2). Some researchers have worked with iron found in water, but their values are different from the values found in soil in ponds in the present study [41, 43].

Table 1: Status of the soil properties of selected fish ponds in relationship with AlP at Taherpur Municipality in Rajshahi District.

Parameters with units	Pond No.	Control	Mean±SD	Treatment with AlP	Mean±SD
pH	Pond 1	6.87±0.49	6.93±0.18	6.97±0.84	7.22±0.31
	Pond 2	6.80±0.61		7.13±0.72	
	Pond 3	7.13±0.06		7.57±0.06	
Organic matter (OM)%	Pond 1	0.99±0.45	1.16±0.20	0.87±0.49	0.89±0.03
	Pond 2	1.12±0.55		0.92±0.37	
	Pond 3	1.38±0.31		0.88±0.62	
Total nitrogen (TN)%	Pond 1	0.06±0.03	0.07±0.01	0.06±0.02	0.06±0.01
	Pond 2	0.07±0.03		0.05±0.02	
	Pond 3	0.08±0.02		0.07±0.01	
Potassium (K) meq/100 g	Pond 1	0.52±0.31	0.59±0.11	0.44±0.24	0.51±0.11
	Pond 2	0.52±0.32		0.47±0.27	
	Pond 3	0.72±0.01		0.63±0.01	
Calcium (Ca) meq/100 g	Pond 1	6.83±0.62	7.06±0.38	6.79±0.94	6.87±0.16
	Pond 2	6.84±1.10		7.06±1.52	
	Pond 3	7.50±0.19		6.77±0.52	
Magnesium (Mg) meq/100 g	Pond 1	1.69±0.39	1.63±0.08	1.60±0.34	1.46±0.18
	Pond 2	1.66±0.23		1.52±0.30	
	Pond 3	1.55±0.07		1.26±0.05	
Phosphorus (P) µg/g	Pond 1	50.33±9.87	52.06±3.13	51.23±18.20	50.29±2.90
	Pond 2	50.17±16.64		47.03±12.87	
	Pond 3	55.67±0.47		52.60±1.25	
Sulfur (S) µg/g	Pond 1	92.87±67.87	108.19±25.96	87.60±55.26	99.32±21.26
	Pond 2	93.53±67.68		86.50±56.76	
	Pond 3	138.17±12.61		123.87±4.86	
Zinc (Zn) µg/g	Pond 1	1.22±0.77	1.46±0.25	1.42±0.45	1.46±0.20
	Pond 2	1.45±0.95		1.29±0.63	
	Pond 3	1.72±0.47		1.68±0.01	
Iron (Fe) µg/g	Pond 1	135.45±18.66	130.85±5.29	124.79±19.54	119.59±7.69
	Pond 2	132.03±13.46		123.22±18.09	
	Pond 3	125.07±2.64		110.76±0.66	

Table 2: Status of the soil properties of selected fish ponds in relationship with rotenone at Taherpur Municipality in Rajshahi District. OM, organic matter; TN, total nitrogen

Parameters with units	Pond No.	Control	Mean±SD	Treatment with Rotenone	Mean±SD
pH	Pond 1	6.87±0.49	6.93±0.18	6.80±0.69	7.02±0.33
	Pond 2	6.80±0.61		6.87±0.67	
	Pond 3	7.13±0.06		7.40±0.10	
OM%	Pond 1	0.99±0.45	1.16±0.20	1.13±0.45	1.27±0.13
	Pond 2	1.12±0.55		1.28±0.34	
	Pond 3	1.38±0.31		1.39±0.20	
TN%	Pond 1	0.06±0.03	0.07±0.01	0.07±0.02	0.07±0.01
	Pond 2	0.07±0.03		0.07±0.03	
	Pond 3	0.08±0.02		0.08±0.01	
K meq/100 g	Pond 1	0.52±0.31	0.59±0.11	0.91±0.63	1.05±0.22
	Pond 2	0.52±0.32		0.93±0.63	
	Pond 3	0.72±0.01		1.30±0.01	
Ca meq/100 g	Pond 1	6.83±0.62	7.06±0.38	7.08±0.77	7.70±0.54
	Pond 2	6.84±1.10		7.98±1.30	
	Pond 3	7.50±0.19		8.04±1.07	
Mg meq/100 g	Pond 1	1.69±0.39	1.63±0.08	1.72±0.41	1.64±0.17
	Pond 2	1.66±0.23		1.76±0.39	
	Pond 3	1.55±0.07		1.45±0.16	
P µg/g	Pond 1	50.33±9.87	52.06±3.13	52.93±13.73	55.89±4.89
	Pond 2	50.17±16.64		53.20±15.17	
	Pond 3	55.67±0.47		61.53±0.67	
S µg/g	Pond 1	92.87±67.87	108.19±25.96	112.10±80.90	127.44±26.15
	Pond 2	93.53±67.68		112.60±78.39	
	Pond 3	138.17±12.61		157.63±6.29	
Zn µg/g	Pond 1	1.22±0.77	1.46±0.25	1.50±0.84	1.66±0.32
	Pond 2	1.45±0.95		1.45±0.93	
	Pond 3	1.72±0.47		2.03±0.05	
Fe µg/g	Pond 1	135.45±18.66	130.85±5.29	143.83±27.69	135.96±9.67
	Pond 2	132.03±13.46		138.89±19.32	
	Pond 3	125.07±2.64		125.17±0.60	

3.2. ANOVA analysis of soil properties

The results of the one-way analysis of variance (ANOVA) of each analyzed parameter e.g., between groups and within groups (control, AlP and rotenone), and the values of the F test and significance are presented in Table 3. The pH, organic matter, total nitrogen, calcium, magnesium, phosphorus, sulfur and zinc showed no significant variations in terms of control and treatment. ANOVA shows significant differences in potassium (F = 6.782, P = 0.0046) and iron (F = 5.273, P = 0.0126) in the soil of fish ponds at the level of $p<0.01$ and $p<0.05$ respectively (Table 3). The finding is in agreement with the earlier accounts of Bhuyan *et al.* [44], who revealed that no significant differences are found in soil quality parameters such as EC, pH, OC and OM. This study is also supported by a previous study that there are no significant differences between total N, K, P, S, As and Ni around the Barapukuria coal mining industrial area [45].

3.3. Correlation analysis of soil properties

According to Pearson correlation, the '*r*' values of pH, OM, TN, K, Ca, Mg, P, S, Zn and Fe showed a positive correlation against AlP and Rotenone with control (Table 4). A very strong positive correlation was recorded for S, K, Fe, pH, Mg, Zn and P between AlP vs control, and for K, S, P, OM, pH, Zn, TN, Mg and OM between rotenone vs control (Table 4). For AlP, the two-trail p values were indicated that only four parameters (out of ten) were showed significant relationships with AlP and control *viz*, Fe ($p<0.001$), Mg ($p<0.01$), K ($p<0.01$) and pH ($p<0.01$) (Table 4). On the other hand, some parameters were also exhibited significant relationships with rotenone vs control *viz*, S ($p<0.001$), K ($p<0.001$), P ($p<0.01$) and Ca ($p<0.05$) (Table 4). More or less similar findings were observed by Bhuyan *et al.* [44], in Sitalakshya river and by Kumar *et al.* [35] in Madhupur tract, Bangladesh. Kumar *et al.* [35]. exposed the positive correlation between the values of N, S, Mg and Ca with pH and the TN, P, Zn and Ca with OM. A recent study exhibited that clay particles with soil pH and soil EC showed a significant positive correlation at $p<0.001$ level [46].

Table 3: One-way analysis of variance (ANOVA) in terms of ponds at Taherpur Municipality in Rajshahi District. ns, not significant, *, $p<0.05$; **, $p<0.01$

Parameters	Source of Variation	Sum of Squares	df	Mean Squares	F	P-value	Level of Sig.
pH	Between Groups	0.394	2	0.197	0.678	0.517	ns
	Within Groups	6.971	24	0.290			
	Total	7.365	26				
OM	Between Groups	0.684	2	0.342	2.173	0.136	ns
	Within Groups	3.778	24	0.157			
	Total	4.461	26				
TN	Between Groups	0.0008	2	0.0004	0.884	0.426	ns
	Within Groups	0.011	24	0.0004			
	Total	0.012	26				
K	Between Groups	1.507	2	0.753	6.782	0.005	**
	Within Groups	2.666	24	0.111			
	Total	4.173	26				
Ca	Between Groups	3.357	2	1.679	2.029	0.153	ns
	Within Groups	19.854	24	0.827			
	Total	23.211	26				
Mg	Between Groups	0.191	2	0.096	1.197	0.320	ns
	Within Groups	1.916	24	0.080			
	Total	2.107	26				
P	Between Groups	147.526	2	73.763	0.624	0.544	ns
	Within Groups	2836.82	24	118.200			
	Total	2984.347	26				
S	Between Groups	3720.761	2	1860.38	0.660	0.526	ns
	Within Groups	67602.09	24	2816.754			
	Total	71322.85	26				
Zn	Between Groups	0.223	2	0.111	0.297	0.746	ns
	Within Groups	9.002	24	0.375			
	Total	9.225	26				
Fe	Between Groups	1106.918	2	553.459	5.273	0.013	*
	Within Groups	2519.233	24	104.968			
	Total	3626.15	26				

Table 4: Correlation among the soil quality parameters at Taherpur Municipality in Rajshahi District. *, $p<0.05$; **, $p<0.01$, ***, $p<0.001$

Parameters		ALP with control	Rotenone with control
pH	Pearson Correlation	0.950	0.959
	P(T<=t) two-tail	0.009**	0.211
	Observations (N)	9	9
OM	Pearson Correlation	0.316	0.812
	P(T<=t) two-tail	0.143	0.240
	Observations (N)	9	9
TN	Pearson Correlation	0.737	0.847
	P(T<=t) two-tail	0.211	0.247
	Observations (N)	9	9

K	Pearson Correlation	0.986	0.999
	P(T<=t) two-tail	0.005**	0.0004***
	Observations (N)	9	9
Ca	Pearson Correlation	0.694	0.667
	P(T<=t) two-tail	0.437	0.038*
	Observations (N)	9	9
Mg	Pearson Correlation	0.882	0.846
	P(T<=t) two-tail	0.003**	0.899
	Observations (N)	9	9
P	Pearson Correlation	0.839	0.967
	P(T<=t) two-tail	0.420	0.004**
	Observations (N)	9	9
S	Pearson Correlation	0.988	0.996
	P(T<=t) two-tail	0.060	0.0002***
	Observations (N)	9	9
Zn	Pearson Correlation	0.839	0.869
	P(T<=t) two-tail	0.994	0.138
	Observations (N)	9	9
Fe	Pearson Correlation	0.969	0.963
	P(T<=t) two-tail	0.00001***	0.056
	Observations (N)	9	9

4. Conclusion

This study was conducted to assess the soil quality parameters in relationship with aluminium phosphide (AlP) and rotenone in selected fish ponds of Rajshahi District in Bangladesh. The findings of this present study conclude that the mean values of the pH and Mg indicated slightly higher within ten parameters than the control values for AlP. But for rotenone, all values were higher except TN compared with control. Based on the present study, it can be concluded that all the soil quality parameters were increased due to applying rotenone, although decreased in the case of AlP except for pH and Mg. It is believed that increasing the soil quality can be very helpful for fish production purposes. ANOVA revealed that only potassium and iron show significant differences between treatment (AlP and rotenone) and control among ten parameters. Although, the correlation coefficient (r^2) proved the positive relationships with all soil parameters. This is a baseline study and future investigation is recommended to assess the effects of soil quality against the AlP and rotenone on fish production and environmental safety.

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6. References

1. BBS. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. 41th edition, Statistics & Informatics Division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh; c2022, p 584.
2. BBS. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. 36th edition, Statistics & Informatics Division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh; c2016, p 559.
3. DoF. Yearbook of Fisheries Statistics of Bangladesh, 2019-20. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh: Ministry of Fisheries and Livestock. 2021;37:127.
4. BER. Bangladesh Economic Review. Chapter 2-GDP, Savings and Investment; c2021, p 11-19.
5. Boyd CE, Munsiri P. Water quality in laboratory soil-water microcosms with soils from different areas of Thailand. Journal of the World Aquaculture Society. 1997;28:165-170.
6. Munni MA, Fardus Z, Mia MY Afrin R. Assessment of pond water quality for fish culture: a case study of Santosh region in Tangail, Bangladesh. Journal of Environmental Science and Natural Resources. 2013;6(2):157-162.
7. Hillary NB, Beard T, Evans CE. Procedures used for soil analysis by the Auburn University soil testing laboratory. Agronomy and Soils Departmental Series Number 106. Alabama Agricultural Experiment Station, Auburn University, Alabama, USA; c1962.
8. Siddique MAM, Barua P, Ghani MH. Comparative study of physico-chemical properties of soil according to the age of aquaculture pond of Bangladesh. Mesopotamian Journal of Marine Science. 2012;27(1):29-38.
9. Vinothkumar R, Sen A, Srinivasan M. Analysis of bottom soil quality parameters of shrimp pond culture in modified extensive method. Journal of Emerging Technologies and Innovative Research. 2018;5(7):123-126.
10. Banerjea SM. Water quality and soil condition of fish ponds in some states of India in relation to fish production. Indian Journal of Fisheries. 1967;14:113-144.
11. Kone B, Yao-Kouame A, Ettien JB, Oikeh S, Yoro G, Diatta S. Modelling the relationship between soil color and particle size for soil survey in ferralsol environments. Soil and Environment. 2009;28(2):93-105.
12. Wurts WA, Durborow RM. Interactions of pH, carbon dioxide, alkalinity and hardness in fish ponds. Southern Regional Aquaculture Center. SRAC Publication No. 464, 1992.
13. Zweig RD, Morton JD, Stewart MM. Source Water Quality for Aquaculture: A Guide for Assessment. World Bank, Washington, DC, US; c1999.
14. Shafi J, Waheed KN, Mirza1 ZS, Zafarullah M. Variation in bottom soil quality with increasing pond age in freshwater aquaculture. Turkish Journal of Fisheries and Aquatic Sciences. TRJFAS1830. 2021;22(2).
15. Hermiyanto B, Winarso S, Kusumandaru W. Soil chemical properties index of tobacco plantation land in Jember District. Agriculture and Agricultural

Science Procedia. 2016;9:181-190.
16. Rana MEU, Hossain S, Tapader MA, Hossain MB, Sarker BS. Effects of pond age and depth on bottom soil nutrients, pH and salinity in commercial aquaculture farm. World Journal of Fish and Marine Sciences. 2017;9(4):25-30.
17. Boyd CE, Bottom Soils. Sediment and Pond Aquaculture. Chapman and Hall. New York; c1995, p 366.
18. Boyd CE, Munsiri P. Phosphorus adsorption capacity and availability of added phosphorus in soils from aquaculture areas in Thailand. Journal of the World Aquaculture Society. 1996;27:160-167.
19. Ali MM, Saheed SM, Daisuke K, Tsugiuki M, Toshiyuki W. Soil degradation during the period 1967-95 in Bangladesh. 1. Carbon and nitrogen, 2. Selected chemical characters. Soil Science and Plant Nutrition. 1997;43(4):863-878, 879-890.
20. Boyd CE, Walley WW. Total alkalinity and hardness of surface waters in Alabama and Mississippi. Alabama Agricultural Experiment Station, Auburn University, Alabama, USA, Bulletin 465; c1975.
21. Arce RG, Boyd CE. Water chemistry of Alabama ponds. Alabama Agricultural Experiment Station, Auburn University, Alabama, USA Bulletin 522; c1980.
22. Jana BB, Sarkar D. Water quality in aquaculture-impact and management: a review. Indian Journal of Animal Sciences. 2005;75(11):1354-1361.
23. Swales S. A review of factors affecting the distribution and abundance of rainbow trout (*Oncorhynchus mykiss* Walbaum) in lake and reservoir systems. Lake and Reservoir Management. 2006;22(2):167-178.
24. Wezel A, Robina J, Guerina M, Arthauda F, Valloda D. Management effects on water quality, sediments and fish production in extensive fish ponds in the Dombes region, France. Limnologica. 2013;43(3):210-218.
25. Ahsan E, Karim Z. Soil management on upland soils of Bangladesh. In: Proceeding of the international conference on the management and fertilization of upland soils in the tropics and sub-tropics; c1998, p 247-251.
26. ADB (Asian Development Bank). Training Manual for Environmental Monitoring. Engineering Science Incorporation, USA; c1994, p 2-26.
27. ECR (Environmental Conservation Rules). Government of the People's Republic of Bangladesh. Ministry of Environment and Forest, Department of Environment, Dhaka, Bangladesh; c1997, p 212-214.
28. Bhuiyan AS, Islam SN, Bhiuyan SS. Seasonal occurrence of some copepods in relation to the physicochemical conditions of a fish pond in Rajshahi, Bangladesh. Fishing Chimes. 2008;28:39-41.
29. Radhakrishnan S, Jaya DS. A study on physico-chemical characteristics of aquaculture pond sediments and its effective utilization for plant growth. Asian Journal of Environmental Science. 2008;3(1):35-38.
30. Akram Z, Hussain S, Mansoor M, Afzal M, Waqar A, Shabbir I. Soil fertility and salinity status of Muzaffargarh District, Punjab Pakistan. Universal Journal of Agriculture Research. 2014;2:242-249.
31. Sheel PR, Chowdhury MAH, Ali M, Mahamud MA. Physico-chemical characterization of some selected soil series of Mymensingh and Jamalpur districts of Bangladesh. Journal of the Bangladesh Agricultural University. 2015;13(2):197-206.
32. Portch S, Islam MS. Nutrient status of some of the more important agricultural soils of Bangladesh. In: Proceedings of International Symposium on Soil Test Crop Response Studies, Bangladesh Agricultural Research Council and Soil Science Society of Bangladesh; c1984, p 97-106.
33. SRDI. Land and Soil Resources Utilization (in Bengali). Thana Nirdeshika Series-Shibganj Thana. Soil Resources Development Institute, Dhaka, Bangladesh; c1996, p 46-52.
34. Ghosh AB, Biswas CR. Potassium responses and changes in soil potassium status with time. Proceeding of International Potassium Symposium. Potash Research Institute of India, New Delhi; c1978, p 379-390.
35. Kumar U, Rashid H, Tithi NH, Mia MY. Status of soil properties in relationship with soil pH in Madhupur tract of Tangail district in Bangladesh. Progressive Agriculture. 2019;30(3):282-287.
36. Henao J, Baanante CA. Estimating rates of nutrient depletion of the agricultural lands of Africa, IFDC Publication, Muscle Shoals, Alabama, USA; c1999.
37. Boyd CE, Tucker CS. Pond aquaculture Watter quality management. Kluwer Academic Publishers, Boston, MA USA; c1998, p 700.
38. Hartman P, Kutý M, Hlaváč D, Regenda J, Vejsada P. Calcium content in pond sediment and its effect on neutralizing capacity of water and fish production. Aquaculture International. 2016;24(6):1747-1754.
39. Boyd CE. Phosphorus: Key to phytoplankton management. Global Aquaculture Advocate. 2007 Jul;10(4):62-4. https://www.globalseafood.org/advocate/phosphorus-key-to-phytoplankton-management/ July/August 2007.
40. Tapader MA, Hasan MM, Sarker BS, Rana EU, Bhowmik S. Comparison of soil nutrients, pH and electrical conductivity among fish ponds of different ages in Noakhali, Bangladesh. Korean Journal of Agricultural Science. 2017;44:016-022.
41. Shahid M, Nayak AK, Shukla AK, Tripathi R, Kumar A, Mohanty S, *et al*. Long-term effects of fertilizer and manure applications on soil quality and yields in a sub-humid tropical rice-rice system. Soil Use and Management. 2013;29(3):322-332.
42. O'Sullivan JN, Asher CJ, Blamey FPC. Nutrient Disorders of Sweet Potato. ACIAR Monograph No. 48, Australian Centre for International Agricultural Research, Canberra; c1997, p 136.
43. Asadi SS, Lahari K, Sai Madhulika K. Analysis of soil quality for environmental impact assessment: a model study. International Journal of Civil Engineering and Technology. 2017 Mar;8:798-805.
44. Bhuyan M, Islam M. Qualitative assessment of sediment from River Meghna, Bangladesh. Bangladesh Journal of Scientific and Industrial Research. 2018 May 27;53(2):89-98.
45. Rahman MM, Howladar MF, Faruque MO. Assessment of soil quality for agricultural purposes around the Barapukuria coal mining industrial area, Bangladesh: insights from chemical and multivariate statistical analysis. Environmental Systems Research. 2017 Dec;6(1):1-3.
46. Shafi J, Waheed KN, Mirza ZS, Zafarullah M. Assessment of soil quality for aquaculture activities from four divisions of Punjab, Pakistan. The Journal of Animal & Plant Sciences. 2021;31(2):556-566.