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Full Length Research Paper

Electroplating Waste Contribution to Soil Phosphorus Dynamics and Its Interaction with Physico-Chemical Properties

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Unorganized land disposal of industrial wastes contaminates land and ground water. The Wazirpur Industrial area of Delhi, a metropolitan city, generates highly acidic (pH 2 - 3.8) and toxic waste, and disposal remains a perpetual problem. This waste contains a high quantity of macronutrients as well as heavy metals because major industries are involved in metals finishing. Wastes of these industries were mixed with municipal waste at roads. Hence a study was undertaken to verify the suitability of land disposal of this toxic waste. The waste was first treated with three doses of lime (0, 0.5 and 1%) and then mixed with two types of soils from two different locations in three different proportions viz. 10, 20 and 30%, maintaining soil moisture level at 50% of water holding capacity. These samples were incubated for 120 days. All three waste amendments resulted in an increase in available phosphorus (AP) in both waste-amended soils as compared to the control soils. It is statistically significant at p = 0.05 level. During the 120 days of incubation highest value (36.41 ± 0.01 ppm for site 1 soil and 30.40 ± 0.03 ppm for site 2 soil) of available phosphorus had been found at 20th day of incubation for both the soils. Lime treatment at the rate of 0.5% gave in 10 and 20% treatments significantly positive result as compared to 0 and 1% treatment. Only in 30% waste amendment 1% lime treatment gave better amount of available phosphorus (27.77 ± 0.01 ppm and 24.84 ± 0.03 ppm for site 1 and site 2 soils respectively). The finding of the study evident that 0.5% lime treated 10% industrial waste can be used as manure for soil. The result is of further interest from a plant nutrition standpoint since the amount of potentially mobile-P measured in this study could be related to the amount of available phosphorous required for crop growth.

Key words: Industrial waste, land disposal, incubation study, available phosphorus.

INTRODUCTION

Today we have several paths of disorganized developmental processes which have led to deterioration soil fertility and depletion of essential micronutrients i.e. intensive cropping, indiscriminate use of chemical fertilizers (Rautaray et al., 2003) and also a consistent release of waste from anthropogenic sources to the environment has resulted in a continuous buildup of toxic waste in soil. Disposal of industrial waste is a major problem in many countries. Dumping of industrial waste in the vicinity of industrial areas causes environmental hazards. Santra, (2000) stated that the global production of hazardous wastes is estimated to be at least 3.38 x 10^{11} kg per annum, about 80% of which is generated in the USA alone. The official report declared that the National Capi-tal Territory (NCT) of Delhi, India, with a population approximately of 14 million, covering an area of 1483 sq km has emerged as one of the biggest centers of small-scale industries in the country. Industrial growth in Delhi has increased from 9600 in 1951 to 126,000 in 1996 (Office of the Commissioner of Industries, Delhi, 1996). Capital is thus highly polluted due to a large number of existing industries. In Delhi, more than 6500 tones of mu-

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nicipal solid wastes are generated every day (MoEF, 2000).

Materials that we no longer need or have no use further use fall in the category of waste; these are classified by their physical, chemical and biological characteristics i.e. solid wastes are contain less than 70% of water. Indus-trial waste is often more heterogeneous in compared with domestic waste. Industrial development in India started during the last two decades and resulted in a lot of severe environmental problems especially in metro and other developed cities.

Disposal of waste on land is an old method to get rid of the huge amount of waste. Land application of organic wastes obtained from different sources (Municipal, Industrial, or zoo technical) has two advantages: it avoids accumulation of wastes in the environment and it pro-vides organic matter and nutrients for the soil. Rautaray et al. (2003) stated that there is one of the possible ways of enhancing productivity of soil is use municipal and industrial waste in appropriate concentration with other medium which may act as a soil amendment and source of nutrient supply system for vegetation. From most of the research works it is proved that the industrial and muni-cipal waste have high amount of N and P (Narwal et al., 1983; National Research Council, 1996; Frossard et al., 1996; Mohammad and Battikhi, 1997). Plants can use this rich source of N, P and K if suitably managed can be done. Phosphorus (P) is an essential macronutrient for plants and one of the three nutrients generally added to soils in fertilizers because of its vital role of energy transfer in living organism and in plants. Adequate P availability stimulates early growth and hastens maturity. In soils P may exist in many different forms. In practical terms, however, P in soils can be thought of existing in 3 three "pools": Solution P, Active P and Fixed P. Most of the P taken up by a crop during a growing season will probably have moved only an inch or less through the soil to the roots. A growing crop would quickly deplete the P in the soluble P pool if the pool were not being continuously replenished.

The solution P pool remains in orthophosphate form, but small amounts of organic P may exist as well plants take only P in the orthophosphate form. The solution P pool is important because it is the pool from which plants take up P and it is the only pool that has any measurable mobility. The active P pool is P in the solid phase, which is relatively easily released to the soil solution, the water surrounding soil particles. The active P pool is the main source of available P for crops and it makes a soil fertile with respect to phosphate. The fixed P pool of phosphate contains inorganic phosphate compounds that are very insoluble and organic compounds that are resistant to mineralization by microorganisms in the soil and phos-phate in this pool may remain in soils for years without being made available to plants and may have very little impact on the fertility of a soil.

A lot of work is done on land application of municipal waste and sewage sludge with a very little work done on industrial waste. Several studies revealed on characteri-zation of industrial waste but unfortunately few of them are study of land application of industrial waste. Hence present study was undertaken to examine the status of available phosphorus in waste amended soils.

MATERIALS AND METHODOLOGY

Study site: The national capital territory of Delhi, with a population of more than 13 million and 24 industrial area is highly polluted and generates about 60,000 tones of solid waste per day (NPC Report 1997; MoEF, 2000) . Among the above said 28 industrial areas Wazirpur Industrial Area is situated northwest part of Delhi, covering an area of 210 acre, is a big source of solid wastes generation, producing more than 30% of total solid waste of Delhi city (Office of the Commissioner of Industries, Delhi, 1996). They are continuously generating metal sheets, rods and different small and large metals products used in building built-up. Waste coming out from these industries is highly acidic having pH between 2 to 3.8. Even the water flowing in the drains has pH of around 1.0 and the waste contains a large quantity of macronutrients and micronutrients (Giri and Bhattacharyya, 1999). 70% of industries occurring at this area are metal pickling industries using high amount of strong mineral acids.

Initially this area had approximately 1000 industries. The main polluting industries, which were in working condition, were electroplating, rolling-pickling and textiles industries. The others are rubber, plastic, soap, electronic goods etc. The entire area was divided into three industrial parts A, B and C. Due to its industrial status, every day huge amount of toxic wastes spewing out of the units, spreading solid waste and effluents on the road side and dwelling places, and resulting in major health problems in this area.

Methodology: We collected 30 waste samples from 3 blocks of study site in three seasons. Samples collected randomly after removing a thin super layer from a depth of 30 cm. Waste samples stored in a transparent polythene bags. Soil was also collected from two other sub sites

That is, Site 1 and Site 2 (Chhattarpur and JNU soil respectively). Fresh samples of waste and soil was taken for pH (Zenar), Electrical Conductivity (Hess, 1971), Moisture Content (%) and Water Holding Capacity analysis (WHC).

Soil pH is a measure of the activity of ionized H in the soil solution. In present study electrometric methods had been followed. A solution of soil and double distilled water is prepared in the ratio of 1:10 in a 100 ml beaker by stirring it with a magnetic stirrer for 10 minutes and pH values were measured after half an hour using a pH meter after standardization.

Electrical conductivity (EC) of a solution is the conductance of the solution at 25^{O}C temperature between electrodes of 1 cm sq. and 1 cm apart. It measures the dissolved salts in a soil solution.

Organic carbon contains soil organic fraction which consist of the cells of microorganisms, plant and animal residues at various stages of decomposition, stable 'humus' synthesized from residues and highly carbonized compound such as charcoal, graphite and coal.

Cation exchange capacity (CEC) is usually expressed in meq./100gm.of soil. CEC is a measure of the quantity of readily exchangeable cations neutralizing negative charges in the soil. A soil leached with a salt solution (1M) has the power to absorb the cations of the percolating solution and to liberate an equivalent amount of other cations (Jackson, 1958).

Both soil and waste samples were air dried and grinded to pass through 2 mm sieve and subjected to a proper mixing. The organic carbon was measured by Walkley and Black Method (1934), Cation exchange capacity by Direct Distillation Method (Jackson 1958) and

Table 1. Physico-chemical characteristics of industrial waste and soils

Sample Name	pH	E.C.	M.C. (%)	W.H.C. (%)	C.E.C.	O.C. (%)	A.P. (ppm)	T.P. (%)
Waste	3.05	1.8	3.5	39	12.21	3.28	42.08	0.28
Chattarpur Soil	8.61	0.12	1.5	37	11.87	0.76	9.25	0.052
JNU Soil	8.37	0.09	2	32	10.78	0.40	13	0.04

Table 2. Correlation between different Physico-Chemical parameters

	pH	E.C.	M.C.	W.H.C.	C.E.C.	O.C.	A.P.
pH	1						
E.C.	**-0.938***	1.000					
M.C.	**-0.979****	**0.956***	1.000				
W.H.C.	0.633 NS	-0.731 NS	0.532 NS	1.000			
C.E.C.	-0.656 NS	0.635 NS	0.438 NS	**0.938***	1.000		
O.C.	**-0..938***	**0.935***	**0.936***	-0.735 NS	0.763 NS	1.000	
A.P.	**-0..937***	**0.932***	**0.930***	-0.644 NS	0.604 NS	**0.976****	1.000

* significant at 1%, NS- non significant

available Phosphorus by Bray's No.1 (1954) for waste samples and Olesen's (1954) for soil.

For the chemical analysis a single representative waste sample was made from each season. This sample was homogenized and first initially treated with lime by adding 0, 0.5 and 1.0% of lime doses. These lime treated wastes were mixed with both soils by percent of soil i.e. 10, 20 and 30%. Control soils and waste amended samples are kept in transparent polythene bags (500 g/bag) and finally these polythene bags were kept in an incubator at 28^{o}C for different time interval viz. 10, 20, 30, 45, 60, 90, and 120 days. The 0th day samples are taken out at the time of incubation and stored at 4^{o}C for further analysis. In our study we maintained the constant moisture content that is, 50% of the water holding capacity (WHC) so it couldn't alter the other physico-chemical properties of samples. Although it has been observed that there is significant positive relation between P mobility and moisture content and water holding capacity. According to proportion of waste and lime, samples were named for e.g. C-0-0 refers to Chhattarpur soil having 0%waste and 0% lime, while C-10-0 means Chhattarpur soil having 10% waste and 0% lime. Same is followed for JNU soil.

All the statistical analysis was done by ANOVA at 5% level (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

Characteristics of waste and soils

The different physico-chemical properties of both soils as well as representative waste sample were depicted in Table 1.

pH is the most important and basic physical property of the soils. Almost every process occurring in the soil is governed by the pH of the soil (Brady, 2000). It was observed that the waste was highly acidic having pH 3.05, as a number of industries in this area is involved in metal finishing processes. Except pH all the other para-meters were found higher in the waste than the soils. The similar finding was also reported by Ritesh and Sihorwala (2003).

The soils at two sites differ in its basic nature i.e. soil at Site 1 is nursery soil without any anthropogenic distur-bances while soil at Site 2 is farmland soil where acti-vities including fertilizers, manures and pesticides are applied to the field to grow vegetables. The soil at Site 2 situated within 5 km radius of Thermal Power Station where fly ash and other pollutant are likely to contaminate the soil. These conditions are responsible for the differ-rences in the few physico-chemical properties of the soils. The soil at both site 1 and 2 were alkaline in nature but Site 2 soil is more alkaline (8.61) as compare to Site 1 (8.36) soil. All the parameters including available phos-phorus were found more in site 1 soil than site 2 soils. (Table 1). Correlations between different parameters stu-died are given in (Table 2).

Incubation study

Soil pH is a measure of the activity of ionized H in the soil solution. The mineralization of phosphorous as well as the transformation of phosphorous from non-available toavailable form is also pH dependent (Brady, 2000). Changes in pH of incubated samples of both soils were significant and the effect of lime can easily be seen (Table 3). Tsalidas et al. (1995) reported an increase in pH by addition of lime when they applied sewage sludge on acidic soil. It was observed that as the percent of waste increased pH decreased as one can expected by addition of acidic waste and this is might be due to decomposition of industrial waste. Harding et al. (1985) and Tastar and Haktanir (2000) also reported a decrease in pH when they applied industrial sewage sludge on

Table 3. Variation in pH of soils treated with waste in different ratio

Sample name	0 Day	10 Day	20 Day	30 Day	45 Day	60 Day	90 Day	120 Day
C-0-0	8.61±0.01	8.41±0.01	8.41±0.01	8.38±0.01	8.03±0.01	7.95±0.01	7.69±0.01	7.6±0.01
C-10-0	8.12±0.01	8.04±0.01	8.35±0.01	8.15±0.01	7.85±0.01	7.88±0.01	7.29±0.01	7.47±0.01
C-10-0.5	8.20±0.01	8.12±0.01	8.49±0.01	8.19±0.01	7.89±0.01	7.89±0.01	7.49±0.01	7.61±0.01
C-10-1.0	8.31±0.01	8.23±0.01	8.58±0.01	8.29±0.01	8.06±0.01	7.93±0.01	7.58±0.01	7.74±0.01
C-20-0	7.69±0.01	7.89±0.01	8.21±0.01	8.01±0.01	7.87±0.01	7.71±0.01	7.56±0.01	7.52±0.01
C-20-0.5	7.78±0.01	8.21±0.01	8.31±0.01	8.10±0.01	7.87±0.01	7.90±0.01	7.59±0.01	7.67±0.01
C-20-1.0	7.82±0.01	8.50±0.01	8.43±0.01	8.16±0.01	7.91±0.01	7.93±0.01	7.64±0.01	7.77±0.01
C-30-0	7.64±0.01	7.64±0.01	8.04±0.01	7.79±0.01	7.78±0.01	7.69±0.01	7.40±0.01	7.44±0.01
C-30-0.5	7.75±0.01	7.87±0.01	8.12±0.01	7.89±0.01	7.76±0.01	7.84±0.01	7.55±0.01	7.61±0.01
C-30-1.0	7.87±0.01	7.91±0.01	8.14±0.01	7.90±0.01	7.79±0.01	7.86±0.01	7.59±0.01	7.63±0.01
J-0-0	8.37±0.01	8.12±0.01	8.8±0.01	8.44±0.01	7.93±0.01	7.78±0.01	6.8±0.01	7.44±0.01
J-10-0	7.38±0.01	7.68±0.01	7.77±0.01	7.77±0.01	7.76±0.01	7.50±0.01	7.52±0.01	7.58±0.01
J-10-0.5	7.71±0.01	7.96±0.01	7.97±0.01	7.93±0.01	7.89±0.01	7.67±0.01	7.64±0.01	7.72±0.01
J-10-1.0	8.36±0.01	8.15±0.01	8.12±0.01	8.02±0.01	8.05±0.01	7.90±0.01	7.77±0.01	7.81±0.01
J-20-0	7.37±0.01	7.78±0.01	7.60±0.01	7.64±0.01	7.80±0.01	7.45±0.01	7.50±0.01	7.53±0.01
J-20-0.5	7.62±0.01	7.91±0.01	7.77±0.01	7.85±0.01	7.92±0.01	7.65±0.01	7.64±0.01	7.75±0.01
J-20-1.0	8.13±0.01	8.09±0.01	7.95±0.01	8.00±0.01	8.00±0.01	7.78±0.01	7.74±0.01	7.84±0.01
J-30-0	7.41±0.01	7.61±0.01	7.52±0.01	7.53±0.01	7.78±0.01	7.48±0.01	7.52±0.01	7.56±0.01
J-30-0.5	7.85±0.01	7.86±0.01	7.77±0.01	7.81±0.01	7.92±0.01	7.62±0.01	7.66±0.01	7.69±0.01
J-30-1.0	8.45±0.01	8.09±0.01	8.00±0.01	7.98±0.01	8.03±0.01	7.75±0.01	7.78±0.01	7.85±0.01

alkaline soils. But through passage of time pH becomes almost neutral value in all cases this is due to soil buf-fering capacity in which all type of soils have a tendency to neutralize their pH (Brady, 2000). A positive significant change is observed when both soils are incubated with lime treated samples (Table 3).

Electrical conductivity is a measure of salt concen-tration and is measured in mS/cm. Change in EC for incubated samples were also remarkable. As the percent of waste increases EC also increased for both the amended soils. The Electrical conductivity in present study was consistent with the finding of Taster and Hoktanir (2000) . The specific trend in EC values of incu-bated samples during passage of time is not observed (Table 4). Similar findings were reported by Tsadilas et al. (1995) and Harding et al. (1985).

With increasing percent of waste, organic matter (OM) of waste also increased (Table 5). No specific trend for OC was found with passage of time but it decreased up to 45 - 60 days and than showed an increase in both soil. Both Site 1 and Site 2 soils followed similar trend about OM. This earlier decrease in the organic matter might be due to the growth and development of microorganisms. They utilize the organic matter present in soil for their early growth. But after 45 days the growth of micro-organisms started to decline phase. This might be the cause for the reduction in OM upto 45 days of incubation in both soils. Khaleel et al. (1981), Tsadilas et al. (1995); Meena et al. (2001) and Tastar and Haktanir (2000) also reported similar observations. Here no change observed in organic matter with the lime treatment of waste - (Table 5). Changes in CEC during incubation study were given into Table 6.

In this study CEC also increased with the addition of waste but after 120th day of incubation period CEC de-clines and becomes lower than the 0th day. Epstein et al. (1976) also reported that industrial sewage sludge increaseed CEC as estimated by exchangeable cations or "effective CEC" and later supported by Cavallaro (1993); Tastar and Haktanir (2000) and Herrick and Wander (1997). They explained that the increment in CEC was due to slight increase in organic carbon. With the increase in lime doses CEC also increases. This increment could be due to presence of high amount of Ca, Mg and K of our wastes.

Available Phosphorus (AP) is present in soil with the mixture of aluminium, iron and calcium phosphate. The relative percentage among these three forms is a function of soil pH, and the higher percentage of Al and Fe phos-phates is found in acid soils, while higher percentage as calcium phosphate found in neutral to alkaline soils (Brady, 2000).

Variation in available phosphorus of control soil and waste amended both soils is depicted in Table 7. With increased percent of waste, the AP also increased for both soils. Barbarick and Workman (1987), McCoy et al. (1986) and Sudarshana and Bhattacharyya (2006) also observed similar finding when they applied sewage sludge on soil. Taha et al. (2006) also reported that with increasing doses of superphosphate AP also increased.

Table 4. Variation in Electrical Conductivity of soils treated with waste in different ratio

Sample name	0 Day	10 Day	20 Day	30 Day	45 Day	60 Day	90 Day	120 Day
C-0-0	0.12±0.01	0.13±0.01	0.14±0.05	0.16±0.02	0.17±0.02	0.13±0.01	0.17±0.05	0.16±0.01
C-10-0	0.41±0.02	0.46±0.01	0.47±0.04	0.49±0.01	0.35±0.01	0.34±0.01	0.43±0.05	0.39±0.01
C-10-0.5	0.38±0.02	0.43±0.02	0.45±0.01	0.45±0.01	0.33±0.01	0.29±0.01	0.39±0.01	0.36±0.05
C-10-1.0	0.37±0.01	0.41±0.01	0.42±0.01	0.42±0.03	0.29±0.01	0.27±0.01	0.37±0.01	0.33±0.01
C-20-0	0.57±0.01	0.65±0.02	0.66±0.03	0.68±0.01	0.47±0.05	0.46±0.01	0.53±0.02	0.51±0.01
C-20-0.5	0.53±0.03	0.62±0.01	0.65±0.01	0.65±0.03	0.44±0.01	0.43±0.01	0.50±0.01	0.45±0.05
C-20-1.0	0.50±0.01	0.59±0.02	0.62±0.02	0.62±0.01	0.40±0.01	0.42±0.01	0.47±0.01	0.38±0.01
C-30-0	0.74±0.02	0.76±0.01	0.78±0.01	0.84±0.02	0.58±0.02	0.53±0.01	0.67±0.01	0.61±0.01
C-30-0.5	0.66±0.01	0.73±0.01	0.77±0.01	0.80±0.01	0.53±0.01	0.50±0.01	0.63±0.05	0.54±0.01
C-30-1.0	0.64±0.01	0.70±0.03	0.72±0.01	0.76±0.01	0.43±0.01	0.45±0.01	0.59±0.01	0.47±0.01
J-0-0	0.09±0.03	0.08±0.03	0.08±0.01	0.07±0.02	0.15±0.03	0.17±0.01	0.16±0.01	0.14±0.05
J-10-0	0.36±0.01	0.33±0.02	0.37±0.03	0.41±0.01	0.45±0.01	0.44±0.01	0.59±0.04	0.55±0.01
J-10-0.5	0.35±0.01	0.31±0.01	0.34±0.01	0.38±0.01	0.38±0.01	0.40±0.01	0.55±0.01	0.52±0.01
J-10-1.0	0.33±0.02	0.28±0.02	0.32±0.01	0.37±0.03	0.35±0.02	0.37±0.01	0.49±0.01	0.49±0.02
J-20-0	0.53±0.01	0.50±0.01	0.54±0.04	0.56±0.01	0.52±0.01	0.54±0.01	1.01±0.01	0.98±0.01
J-20-0.5	0.51±0.01	0.49±0.01	0.52±0.01	0.55±0.01	0.51±0.01	0.54±0.01	0.94±0.03	0.97±0.01
J-20-1.0	0.47±0.05	0.48±0.01	0.47±0.01	0.48±0.02	0.49±0.02	0.53±0.01	0.90±0.01	0.96±0.01
J-30-0	0.64±0.01	0.62±0.05	0.65±0.04	0.70±0.02	0.61±0.01	0.70±0.01	1.20±0.01	1.26±0.05
J-30-0.5	0.61±0.06	0.60±0.01	0.62±0.01	0.65±0.03	0.58±0.01	0.67±0.01	1.20±0.02	1.23±0.01
J-30-1.0	0.58±0.02	0.58±0.05	0.60±0.02	0.63±0.03	0.54±0.03	0.59±0.01	1.14±0.01	1.17±0.02

Table 5. Variation in Organic Carbon (%) of soils treated with waste in different ratio

Sample name	0 Day	10 Day	20 Day	30 Day	45 Day	60 Day	90 Day	120 Day
C-0-0	0.61±0.01	0.73±0.01	0.59±0.05	0.65±0.01	0.56±0.05	0.6±0.02	0.58±0.01	0.65±0.01
C-10-0	0.91±0.01	1.02±0.01	1.06±0.01	1.00±0.01	0.93±0.01	0.97±0.01	0.98±0.01	1.20±0.01
C-10-0.5	0.93±0.01	1.04±0.01	1.07±0.01	1.00±0.01	0.94±0.01	0.96±0.02	0.98±0.01	1.19±0.01
C-10-1.0	0.94±0.05	1.04±0.05	1.07±0.05	1.00±0.05	0.94±0.02	0.96±0.01	0.98±0.05	1.19±0.05
C-20-0	1.17±0.01	1.07±0.01	1.07±0.01	1.01±0.01	0.94±0.01	1.02±0.01	1.01±0.01	1.24±0.01
C-20-0.5	1.17±0.04	1.08±0.01	1.07±0.01	1.04±0.01	0.95±0.01	1.01±0.01	1.01±0.01	1.24±0.02
C-20-1.0	1.25±0.01	1.08±0.02	1.07±0.06	1.04±0.06	0.94±0.02	1.03±0.05	1.01±0.05	1.23±0.01
C-30-0	1.57±0.01	1.44±0.01	1.64±0.01	1.60±0.01	1.56±0.01	1.56±0.01	1.41±0.01	1.45±0.01
C-30-0.5	1.57±0.01	1.46±0.03	1.66±0.01	1.60±0.01	1.56±0.01	1.56±0.01	1.42±0.01	1.35±0.04
C-30-1.0	1.58±0.02	1.45±0.01	1.66±0.06	1.61±0.03	1.55±0.06	1.58±0.06	1.41±0.05	1.46±0.01
J-0-0	0.61±0.01	0.65±0.01	0.66±0.01	0.61±0.01	0.71±0.01	0.76±0.01	0.68±0.01	0.71±0.01
J-10-0	0.99±0.01	0.95±0.02	1.01±0.01	1.02±0.01	0.88±0.01	0.80±0.01	0.82±0.01	1.07±0.01
J-10-0.5	1.01±0.04	0.95±0.01	1.01±0.06	1.02±0.02	0.87±0.01	0.80±0.05	0.83±0.01	1.09±0.02
J-10-1.0	1.01±0.01	0.95±0.02	1.01±0.01	1.01±0.01	0.88±0.05	0.81±0.01	0.83±0.05	1.09±0.01
J-20-0	1.40±0.01	1.32±0.01	1.26±0.01	1.31±0.01	1.20±0.01	1.24±0.01	1.12±0.01	1.22±0.01
J-20-0.5	1.40±0.02	1.32±0.03	1.25±0.01	1.30±0.03	1.21±0.01	1.24±0.05	1.13±0.05	1.23±0.01
J-20-1.0	1.39±0.01	1.32±0.01	1.25±0.05	1.31±0.01	1.20±0.01	1.25±0.01	1.13±0.01	1.24±0.03
J-30-0	1.79±0.01	1.64±0.03	1.55±0.01	1.51±0.01	1.54±0.04	1.46±0.01	1.35±0.01	1.23±0.01
J-30-0.5	1.80±0.02	1.64±0.01	1.55±0.01	1.51±0.03	1.54±0.01	1.47±0.04	1.36±0.06	1.23±0.01
J-30-1.0	1.79±0.01	1.65±0.05	1.54±0.03	1.52±0.01	1.54±0.02	1.47±0.01	1.35±0.01	1.23±0.05

Lowering of pH, increasing in EC and CEC also helps in understanding the increment in AP. Tastar and Haktanir (2000) observed that pH is negatively correlated with availability of P while EC and CEC are positively correlated with it. But availability of P is most abundant between 6 - 8 ranges of pH (Brady, 2000). So in present

Table 6. Variation in Cation Exchange Capacity of soils treated with waste in different ratio

Sample name	0 Day	10 Day	20 Day	30 Day	45 Day	60 Day	90 Day	120 Day
C-0-0	11.05±0.01	10.37±0.01	10.37±0.01	13.88±0.05	11.08±0.02	10.18±0.04	9.89±0.02	58±0.05
C-10-0	11.46±0.01	10.73±0.01	11.87±0.01	13.31±0.01	10.60±0.01	9.85±0.01	9.28±0.01	9.15±0.01
C-10-0.5	12.14±0.01	11.37±0.01	12.59±0.05	14.18±0.01	11.24±0.03	10.64±0.01	9.67±0.01	9.73±0.01
C-10-1.0	11.94±0.05	10.86±0.01	12.07±0.01	12.22±0.04	11.48±0.01	11.66±0.02	10.77±0.03	10.58±0.06
C-20-0	12.26±0.01	11.45±0.03	12.90±0.01	13.94±0.01	12.93±0.01	12.40±0.01	10.88±0.01	10.28±0.01
C-20-0.5	12.80±0.01	12.20±0.01	13.47±0.05	14.28±0.02	13.26±0.04	12.19±0.01	11.23±0.01	10.95±0.01
C-20-1.0	13.40±0.06	12.35±0.03	13.64±0.01	12.61±0.01	13.02±0.01	12.35±0.04	10.75±0.02	9.82±0.04
C-30-0	14.61±0.01	13.06±0.01	14.84±0.05	14.25±0.01	13.67±0.02	12.05±0.01	11.67±0.01	9.68±0.01
C-30-0.5	14.62±0.01	14.02±0.01	15.49±0.01	14.32±0.03	15.11±0.01	13.33±0.03	12.97±0.01	10.56±0.03
C-30-1.0	11.07±0.02	10.81±0.03	10.95±0.05	11.55±0.01	9.40±0.01	9.11±0.01	9.01±0.02	9.00±0.01
J-0-0	10.78±0.01	9.92±0.01	8.71±0.01	9.72±0.01	10.28±0.04	9.29±0.01	9.23±0.01	9.13±0.01
J-10-0	11.19±0.01	11.17±0.01	10.69±0.01	11.21±0.01	11.70±0.01	11.22±0.02	10.70±0.01	10.47±0.02
J-10-0.5	11.63±0.03	11.48±0.02	11.19±0.04	11.96±0.01	12.07±0.01	11.69±0.01	11.41±0.03	10.77±0.01
J-10-1.0	11.87±0.01	12.02±0.01	11.76±0.01	11.93±0.01	12.24±0.03	12.22±0.03	11.66±0.01	11.38±0.01
J-20-0	11.84±0.01	11.41±0.01	11.54±0.03	12.50±0.01	12.83±0.01	12.02±0.01	11.70±0.01	11.23±0.03
J-20-0.5	12.40±0.02	12.10±0.02	12.12±0.01	12.80±0.05	12.78±0.01	12.19±0.05	11.75±0.03	11.10±0.01
J-20-1.0	13.12±0.01	12.48±0.01	12.86±0.02	13.71±0.01	13.01±0.04	12.57±0.01	11.64±0.01	11.16±0.01
J-30-0	12.77±0.01	12.42±0.03	12.92±0.01	12.54±0.01	13.31±0.01	12.32±0.05	11.09±0.01	10.31±0.02
J-30-0.5	13.30±0.02	13.35±0.01	13.68±0.01	13.53±0.03	13.57±0.01	13.00±0.01	12.38±0.03	11.02±0.01
J-30-1.0	14.09±0.02	13.96±0.03	14.17±0.04	13.78±0.01	14.07±0.03	12.95±0.01	12.40±0.01	11.19±0.02

Table 7. Variation in Available Phosphorous of soils treated with waste in different ratio

Sample name	0 Day	10 Day	20 Day	30 Day	45 Day	60 Day	90 Day	120 Day
J-0-0	13.01±0.01	16.52±0.02	19.94±0.03	15.72±0.01	12.61±0.01	10.25±0.05	8.60±0.04	5.50±0.01
J-10-0	17.44±0.01	21.25±0.01	27.13±0.01	22.00±0.01	18.57±0.01	15.49±0.01	11.61±0.01	9.18±0.05
J-10-0.5	18.92±0.02	26.44±0.01	31.15±0.01	27.34±0.05	22.56±0.04	19.01±0.01	15.34±0.01	11.64±0.01
J-10-1.0	17.77±0.01	23.20±0.03	28.59±0.03	24.47±0.01	21.34±0.01	16.82±0.05	14.01±0.01	10.58±0.01
J-20-0	21.73±0.01	24.37±0.01	29.25±0.01	25.06±0.01	21.44±0.02	15.49±0.01	12.25±0.03	9.72±0.03
J-20-0.5	24.94±0.03	28.51±0.01	32.41±0.01	27.97±0.03	23.31±0.01	17.98±0.01	13.25±0.01	10.85±0.01
J-20-1.0	24.61±0.01	26.70±0.03	32.03±0.03	26.69±0.01	23.21±0.02	17.39±0.04	13.01±0.01	10.20±0.01
J-30-0	24.64±0.01	27.96±0.01	30.75±0.05	26.49±0.01	23.12±0.01	19.42±0.01	15.50±0.02	10.57±0.02
J-30-0.5	26.91±0.05	30.85±0.01	35.80±0.01	29.15±0.03	25.93±0.02	22.41±0.01	17.96±0.01	13.10±0.01
J-30-1.0	27.77±0.01	31.68±0.02	36.41±0.01	31.07±0.01	28.44±0.01	23.62±0.03	20.60±0.01	14.87±0.01
C-0-0	9.25±0.01	10.35±0.01	11.12±0.01	8.98±0.01	6.56±0.03	5.72±0.01	5.28±0.01	5.00±0.05
C-10-0	14.74±0.04	18.22±0.01	21.57±0.06	17.08±0.04	13.74±0.01	12.01±0.01	8.05±0.02	5.07±0.01
C-10-0.5	15.85±0.01	21.31±0.04	25.63±0.01	21.29±0.01	17.40±0.01	15.16±0.01	10.39±0.01	7.15±0.01
C-10-1.0	15.95±0.03	20.09±0.01	24.82±0.01	20.06±0.01	16.92±0.06	14.47±0.02	8.73±0.03	6.09±0.01
C-20-0	17.64±0.01	19.76±0.01	22.97±0.04	19.74±0.03	17.40±0.01	14.44±0.01	9.41±0.01	7.05±0.03
C-20-0.5	18.65±0.01	21.73±0.01	24.93±0.01	22.42±0.01	18.90±0.01	15.56±0.01	12.28±0.01	9.35±0.01
C-20-1.0	17.99±0.04	20.40±0.03	23.91±0.01	21.34±0.01	18.07±0.01	15.32±0.01	11.70±0.01	8.16±0.01
C-30-0	21.21±0.01	26.16±0.01	26.47±0.04	23.07±0.03	19.61±0.05	13.37±0.02	9.24±0.02	7.09±0.02
C-30-0.5	24.13±0.01	28.06±0.01	28.75±0.01	25.68±0.01	21.57±0.01	15.68±0.01	11.55±0.01	9.23±0.01
C-30-1.0	24.84±0.03	28.45±0.02	30.04±0.03	25.83±0.02	22.29±0.03	15.86±0.03	11.09±0.03	9.47±0.03

Notation: all the values are mean of three values with standard deviation
Notation e.g.J/C1 -102- 0.5%3: 1-JNU/ Chhattarpur soil; 2-percentage of the waste; 3-percentage of lime treatment

study, 0.5% lime dose gave better results in both waste amended soils. But this pattern was followed by only 10 and 20% waste treated soils. 1.0% lime did not show positive relation, this may be due to formation of trical-cium phosphate, which is not an available form of P. For 30% waste treatment 1% lime gave better results for available phosphorus. This could be due to the fact that the acidic nature of the waste needs more lime to be-come neutralized. In present study available phosphorus of Site 2 soils increased up to 20th day of incubation period after which it decreased continuously and reduces upto 42% of its original at the end of the study. Reduction in availability of available phosphorus was due to fixation of phosphorous and uptake of P by microorganisms of soil. Tastar and Haktanir (2000) also found that after 140 days of incubation period available phosphorus high at the beginning of the incubation period and they asso-ciated it with sewage sludge and other organic amend-ments. In our study same pattern was followed by Site 1 soil, also AP increased up to 20th day and then it de-creased, but waste amended in Site 2 soil has more available phosphorous in comparison to waste amended in Site 1 soil.

We have done ANOVA to find out whether the data are significant or not. We first took the days of incubation and lime treatment while on the second day of incubation waste treatment for both soils and are found to be significant at 5% level.

Conclusion

Value addition and utilization of this type of waste as a raw material for crop production with suitable techno-logies is the need of the day. Nutrient beings the major constraints in the development of the modern agriculture. Harvesting the nutrient energy from biological and Indus-trial waste is of prime importance for maximizing the food grains production in the world. In our study, waste was very acidic in nature. A decrease in pH of incubated samples was found with the addition of waste but with the passage of time pH of waste amended soil samples was almost neutral value due to the soil's own buffering capa-city. Organic carbon also increased with the addition of waste in both soils and more so at the end of experiment than the starting. In our study CEC also increased with the addition of waste due to high content of cations in the waste but after 120th day of incubation period it was found lower than starting of incubation study. This reduction was due to incorporation of cations in microorganisms. The availability of phosphorous increased up to 20th day of incubation for both the soils. After 20th day of incuba-tion available phosphorous of the amended soils was found to be considerably decreased because of high rate of P-fixation in soil. The 0.5% lime treatment gave better results because at this lime dose availability of phos-phorous is high. But it was applicable in only up to 20% waste amended soils. For 30% waste amended soils 1.0% lime treatment gave better results. This study was focused on determining potentially mobile-P associated with rainwater percolation. The result is of further interest from a plant nutrition standpoint since the amount of potentially mobile-P measured in this study could be related to the amount of potentially crop available phos-phorous. One always thinks of the economically bene-ficial side of any experiment. Here we tried to find a method of decreasing the hazard ness of industrial waste. From the results the status of available phos-phorous showed that this waste could be used as manure. If one grows plants or crops in this waste amended soil there is no need of further providing any phosphorous fertilizers up to 20th day. It is known that the utility of phosphorous for plant growth is highest at the time of flowering and fruiting. Though this not being the only consideration of the experiment, we should also consider the time of cropping, type of waste, type of soil, mobility of available phosphorous and moisture content of the soil. By considering all these factors cumulatively and in congruency one can easily reduce the volume and ha-zard ness of industrial waste.

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