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Geochemistry and Microbial Population of Soil Samples in Different Sites of Clay Mining Area, Thiruvananthapuram, Kerala, India

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Abstract

The opencast mining deteriorates the environment in numerous ways; it harms most to the soil and water. Thus, estimation of quality of soil and water is extremely important for proper assessment of the associated hazards. The mining industry contributes natural resources to meet social needs, while causing drastic alterations of the landscape which result in unproductive land and change their whole characteristics including physical, chemical and biological properties. In the present study, the soil samples were collected from the pre-mined (PR) virgin area and post-mined (PT) afforested area in a clay –mining site for Physico-chemical and microbiological analysis. All the result were interpreted by using statistical tools such as t-test, correlation coefficient and principal component analysis (PCA).The parameters selected for the analysis were texture, particle size distribution, bulk density, moisture content, pH, EC, OC, OM ,N, P, K, S, Fe, Mn, Cu, Zn, B, CEC, Na, K, Ca, Mg, Bs, MC and microbial population. Among these parameter ,the t-test showed N, MC, B,CEC and B was significant difference between the sites and many of the characteristics were positively correlated with each other and the bacterial count were recorded as the mean difference between the sites are 16.45±0.12 in PR and 19.36±0.12 in PT. The quantification of bacteria revealed that there was significant difference between the sites. The PCA were conducted by considering all the Physico-chemical characteristics were taken as independent variables and microbial populations were dependent variables. Here all the components were categorised into three factors (F1-F3). In site PR, the F1 and F3 were positively correlated with microbial populations and in PT, F1 were positively loaded with the microbial populations. The Mining activities lead to stress conditions and the restoration of mined areas requires the establishment of self-sustainable ecosystem by means of adequate soil –microbe interactions and nutrient released rates.

Key words: *Open cat mining, Physico-chemical properties, Principal component analysis*

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Introduction

Day by day as the mining activity increases it gives a huge impact on our environment. The impact of mining on all the natural resources which can possess the effect on human as well as soil, water, air, organisms, social values, and climatic conditions. Mining severely alters the landscape, which reduces the value of the natural environment in the surrounding land. Surface mining disrupts virtually all aesthetic elements of the landscape. Alteration of landforms often imposed unfamiliar and discontinuous configurations. The soil removed from the area to be surface-mined alters or destroys many natural soil characteristics and reduces its biodiversity and productivity for agriculture. Soil structure may be disturbed by pulverization or aggregate breakdown of the entire natural areas.

Soil is polluted due to disposal of industrial or mining and domestic solid wastes, wet and dry deposition from the atmosphere, infiltration of contaminated water and acid mine drainage (Unni and Fole, 1999; Chakraborty, 2000; Aswathanarayana, 2003; Singh and Singh, 2004). Thus, several changes occur in the physical, chemical and microbiological properties of soil and soil fertility gradually deteriorates year by year.Top soil should be preserved in order to restore and reclaim the mined land (Ghose, 2004; Kundu and Ghose, 1994). Every year large areas are continually becoming unfertile due to opencast mining. Mining causes drastic disturbances in landscape and soil properties, and reclamation can restore soil quality over time. Thus, assessing changes in properties of reclaimed mine soils is essential to understanding the effects of the reclamation techniques. To quantifying the effects of mining and reclamation processes the proper understanding of Physico-chemical and biological properties of reclaimed soils (Raj .K.Shrestha et.al.2011).

Different sizes of soil particles and aggregates in infinite combination result in a highly diverse physical environment with heterogeneity readily displayed at very fine scale (Heijnen *et al.*, 1993; Grundmann, and Debouzie, 2000).The diversity of physical characteristics of soil can harbour a large diversity of microorganisms in close proximity due to the minute size microorganisms. Furthermore, the relationships between microorganisms and soil particles are fully interactive: while soil particles control the survival and biological activity of microorganisms (Chenu, and Stotzky, 2002), soil microorganisms influence soil structure by modifying the soil particles' arrangement or providing cohesive materials to help form and stabilize aggregates (Kiem, and Kandeler, 1997; Bossuyt *et al.*, 2001). Therefore, in this study the soil physico-chemical characteristics together with microbial function can provide important information when evaluating soil reclamation or restoration of mined areas.

Materials and Methods

Study area

The study area lies between $8^0$35' and $8^0$40'N lat. And $76^0$50' and $76^0$55' E long. At Karamoodu, this is a small junction about 2 km east of Mangalapuram, about 27 km northeast of Trivandrum city, on the Mangalapuram- Pothencode road. The topography of the area is gently undulating, and it is composed of a broad lateritic plateau, and valleys. The entire terrain forms part of the tertiary sedimentary sequence resting on a kaolinised genesis. Clay mining activity takes place in an area of 1.34 ha.The pond selected for the present study had an irregular shape; size, shape and depth of the pond will vary according to clay mining activities.

Collection of soil samples

In order to study the physico-chemical characteristics of the soil, the soil samples from different sites such as Pre-Mined Soil as topsoil (PR), Post-Mined Soil as afforested topsoil (PT) were collected from the study area. For the analysis, the topsoil is collected from the virgin area were without mining activities and afforested topsoil were collected from rehabilitated area of mine site. Samples were collected monthly from the study area during the year December 2012-2013 and 2013-2014 respectively.After collection, the soil samples brought to the laboratary and seperated into two sub samples; one for bacteriological analysis that was kept in the refrigerator and other one for the analysis of soil physico-chemical analysis.

Data Analysis

The soils were analysed for various parameters such as pH, electrical conductivity, organic carbon and organic matter available major nutrients such as nitrogen ,phosphorus, potassium, sulphur, available micronutrients such as Fe, Mn, Cu, Zn, and B, texture and particle distribution, cation exchange capacity, exchangeable bases such as Na, K, Ca & Mg, base saturation, moisture content and bulk density. The methods followed for analysis of Physico-chemical characteristics of soil samples. The collected samples were dried in shade and sieved through 2 mm sieve and stored in clear containers with proper labelling for laboratory analysis (Thahir Ali & Sumati Narayan 2009) and (P.K. Gupta, 2001). The bacteriological analysis were carryout by serial dilution plate technique and the discrete colonies were counted (Cappuccino and Sherman, 2008).The statistical data analysis was done by SPSS 16.0 version was used to find out the mean and standard error and the significance on mean difference were statistically tested by using independent sample t-test taking significant level at $p<0.05$ level. Karl Pearson's correlation coefficient was calculated by taking significant level at at 0.01 levels (2-tailed) and 0.05 levels (2-tailed) respectively. The principal component analysis (PCA) was carried for finding significant components which causes variations in the parameters of both sites.

Result and Discussion

Texture and particle size distribution

Texture refers to the relative proportion of different size groups such as sand, silt and clay. According to Weindorf and Zhu, 2010 and Kavianpoor et ,al. 2012 mentioned that the variations of soil texture in small scale with in same type of geological locations. The particle size distribution of the soil samples showed no significant difference among both sites PR and PT. It showed that (Table.2) these particles clay content were comparatively higher than other sand particles and silt content. The clay content was higher in natural pre-mined area than post-mined area. The varying particle size distribution of this result was agreed by other studies. According to Osman, 2012 the particle size distribution takes time to be altered.

Bulk Density

In this results confirmed that higher bulk density were observed in Pre-mined area tha post-mined areas and have no significant difference among the sites(Table .2).Similar results were observed in the studies of Ray et.al.,2006 reported that ,bulk density, particle density and porosity were varied due to variation in land use system.

Moisture Content

In the present study the moisture content was no significant difference between the sites. Here (Table.2) the observed moisture content was higher in pre-mined virgin soil (PR) than post-mined (PT) afforested area. Here the reason for the variations might be due to the textural differentiation and also the post –mined area deprived of heavy vegetation increasing the rate of evaporation than pre-mined areas. The similar result were observed in the studies of Sadeghi et.al., 2007, stated that in the absence of plant cover water infiltration rate during rain fall directly affects the soil moisture content.

Table.2. The data and test of significance for the comparison of mean difference of various physical parameters PR and PT

Parameter		Sites	Mean ± SE	t	Sig (p value)
Texture		PR	Sandy clay		
		PT	Sandy clay loam	----	---
Particle size Distribution	Sand	PR	0.63±0.025	0.186	0.856
		PT	0.62±0.046		
	Silt	PR	1.65±0.375	- 1.885	0.089
		PT	8.65±3.696		
	Clay	PR	35.08±2.092	2.578	0.028
		PT	29.38±0.702		
Bulk density		PR	1.36±0.069	0.854	0.413
		PT	1.27±0.084		
Moisture content		PR	1.61±0.499	2.106	0.061
		PT	0.53±0.120		

Soil pH

Soil pH sampled from the study area, the average pH level on the sites have no significant difference ($p>0.05$ is 0.405). The mean difference of pH level in PR (5.516±0.060) and PT (5.583±0.047) were reported to be more or less same and it was an acidic nature in both sites as depicted on Table 3. The increased pH was observed in post-mined afforested area (PT) than pre-mined natural area (PR).The difference is occurred due to many factors, but the soil type play a vital role. Both the sites were showed medium acidic. It was agreed by Osman acidity rating (Osman, 2012).

Electrical Conductivity (EC)

Electrical conductivity of the soil samples showed no significant difference between the sites ($p>0.05$ is 0.099).The mean difference of EC in the pre-mined natural soil (PR) showed 0.073±0.010 and at the post-mined afforested soil (PR) showed 0.136±0.033(Table.3).This result of the EC values was observed that a slight increase occurred in PT than PR. Here the result showed that EC of pre-mined area (PR) was lower than the post-mined area(PT) because the post-mined area having sloppy region facing soil erosion during rainy season and in addition to these the soil in this area were collected and refill from different parts of the study area. That may give rise to increase in salt concentration. According to Dutta and Ram, 1993 reported the similar results in their study.

Organic Carbon and Organic matter (OC &OM)

The percentage organic carbon and organic matter in both sites showed that no significant difference among the sites ($p>0.005$ is 0.099, 0.019). The average mean difference of OC in PR and PT were 0.973±0.176 and 0.940±0.393 respectively. It was found that ,the observed values of the OC in both sites were more or less same and the OM of the selected study areas PR and PT showed that 1.366±0.179 and PT 1.055±0.430. Here the observed values were also more or less same (Table.3). Among these results found that, the OC and OM were little to be higher in pre-mined areas (PR) than Post-mined areas (PT). In the present study, organic carbon and organic matter were higher in pre-mined soil (PR) than post-mined (PT) soil. There is no significant difference were observed in both sites. The increasing percentage of both parameters sustain soil fertility by improving soil structure, retention of mineral nutrients and it was due to the mixed vegetation profile were showed comparatively higher in pre-mined area than other site. The observed similarity of both parameters helps to increase the amount of soil flora and fauna (Jain, et.al., 2010).

Table .3. The data and test of significance for the comparison of mean difference of various chemical parameters (pH,EC,OC and OM) between PR and PT

Parameter	Sites	Mean ± SE	t	Sig (p value)
pH	PR	5.516±0.060	-0.869	0.405
	PT	5.583±0.047		
EC	PR	0.073±0.010	- 1.817	0.099
	PT	0.136±0.033		
OC	PR	0.973±0.176	0.077	0.940
	PT	0.940±0.393		
OM	PR	1.366±0.179	0.668	0.519
	PT	1.055±0.430		

Available Macro Nutrients (N, P, K, S)

In the present study, the available macro nutrients such as nitrogen, phosphorus, potassium and sulphur were taken into account. The study revealed that the percentage nitrogen content was showed significant difference ($p<0.05$) but the others were not showed statistically significant ($p>0.05$). Among the macronutrients, the percentage of N, K and S were higher in PR than PT but in the case of P content was higher in PT than PR (Table.4). The study revealed that there was a significant difference in the available nitrogen percentage of the study area ($p<0.05$ is 0.000). Available phosphorus, available potassium content, and available sulphur content were no significant difference were noticed in both sites ($p>0.05$ is 0.895, .477, 0.249).The average mean difference of the pre-mined natural soil (PR) was 166.5±1.172 and 70.018±0.637 for post-mined afforested soil (PT) ,the P that in PR 16.970±1.151 and 17.565±4.262 for PT, K in PR 32.781±10.892 and in PT was 24.656±1.455 and in pre-mined soil

(PR) ,the S was found that 46.681±20.169 and in post-mined area (PT)showed that 21.833±2.455 respectively. In the present study revealed that there is no Significant difference among the parameters except the percentage available Nitrogen. By considering the result the available N concentration were higher in PR and PT and the percentage available K, available S were somewhat higher in PR except available phosphorus. The similar results were observed in the studies of Singh and Sharma, 2007 noted that the quantity and quality of litter were imparting the concentration of nutrient enrichment, in appropriate decomposition rate and weak nutrient release to the soil.

Table 4. The data and test of significance for the comparison of mean difference Available Macro Nutrients (N,P,K and S) between PR and PT

N	**PR**	**166.5±1.172**	**72.336**	**0.000**
	PT	70.018±0.637		
P	PR	16.970±1.151	- 0.135	0.895
	PT	17.565±4.262		
K	PR	32.781±10.892	0.739	0.477
	PT	24.656±1.455		
S	PR	46.681±20.169	1.223	0.249
	PT	21.833±2.455		

Available Micro Nutrients (Fe,Mn,Cu,Zn,B)

The available micronutrients such as Iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn) showed that statistically there was no significant difference ($p>0.05$ for Fe, Mn, Cu and Zn) but in the case of boron (B) showed marked significance between the sites ($p<0.05$). In the present study (Table.5) statistically the available Fe, Mn, Cu ,Zn were no significant difference between the soil samples of the study area ($p>0.05$ is 0.317, 0.827, 0.645, 0.101) but there was a significant difference in the available boron content of the study area ($p<0.05$ is 0.005). The average mean difference of in the Fe content of the soil samples in the study area PR and PT was 17.678±0.584 and 29.536±11.245 respectively. Mn in PR and PT were 2.025±0.218 and 2.201±0.754. The copper content in the study area were found that in pre-mined area (PR) was 0.550±0.095 and in post-mined area (PT) was 0.493±0.071. The zinc content in the soil samples revealed that, in the pre-mined area (PR) was 0.631±0.111 and post-mined area was 0.980±0.157. But the average means difference in Boron (B) concentration were showed that, 2.383±0.337 for PR and 1.016±0.192 for PT. In the present study among the soil micronutrients (Fe,Mn,Cu,Zn and B) , available Fe content were higher in post-mined area (PT) than Pre-mined area (PR) and the remaining parameters were no significant difference between the sites. The studies related to the micronutrient status of soil series collected from Sindh province of Pakistan, Dahar,et.al.,2014 reported that the soils around the study area were generally adequate and comparatively higher in Fe than Mn.

Table 5. The data and test of significance for the comparison of mean difference Available Micro Nutrients (Fe, Mn, Cu, Zn and B) between PR and PT

CEC	**PR**	**2.500±0.506**	**2.892**	**0.016**
	PT	0.920±0.204		
Na	PR	0.061±0.011	- 1.544	0.154
	PT	0.386±0.210		
K	PR	0.171±0.634	- 0.858	0.411
	PT	0.258±0.094		
	PT	0.368±0.102		
Mg	PR	0.225±0.035	0.437	0.671
	PT	0.190±0.071		
BS	PR	34.085±5.316	3.009	0.013

Cation Exchange Capacity (CEC)

The study revealed that there was a statistically significant difference in the cation exchange capacity of both soils in the study area ($p<0.05$ is 0.016) .Table.6 showed the average mean difference of the cation exchange capacity of pre-mined area (PR) were 2.500±0.506 and in post-mined area (PT) was 0.920±0.204 .The observed results of CEC were higher in pre-mined (PR) virgin soil than post-mined area reclaimed soil (PT).The variation is due to the virgin soil become clay rich area ready to be selected for next mining purposes. But the post mined soils are infertile with acidic nature CEC also low and poor nutrients. According to Bhaskar,et.al.,2005 .the CEC values are in correspondence to their clay content in the respective horizons. It is agreed with the present result.

Exchangeable Bases (Na,K,Ca,Mg)

The results of the analysis of exchangeable bases Na,K,Ca and Mg revealed that there is no significant difference between the soil samples of the study areas ($p> 0.05$=0.154, 0.411, 0.607 and 0.671). It also revealed that, among the exchangeable bases, Na,K and Ca content were higher in PT than PR (Table.6). But Mg content was higher in PTR than PT. The sodium content showed the observed average mean difference between the soil samples noticed that, in PR 0.061±0.011and in PT was 0.386±0.210. The potassium content in PR 0.171±0.634 and in PT was 0.258±0.094.,the calcium content in the pre-mined area (PR) were 0.308±0.047 and in post-mined area (PT) was 0.368±0.102 and the magnesium contents in the soil samples of the study area PR and PT was 0.225±0.035 and 0.190±0.071 respectively. The exchangeable bases such as sodium, potassium, calcium and magnesium in the present study revealed that all the bases did not show similar trends in land use types. In PR the concentrations of exchangeable bases are $Ca^{2+}>Mg^{2+}>K^{+}>Na^{+}$ and in PT were $Na^{+}>Ca^{2+}>K^{+}>Mg^{2+}$.Such variations in the observed results was due to the change in land use and topography of the study area. The similar result was stated by Awdengest et.al., 2013.the concentration of exchangeable Na^{+} ions was the smallest component in the exchangeable complexes and K^{+} ions are also significantly varied with land use types.

Table. 6. The data and test of significance for the comparison of mean difference CEC, Exchangeable Bases and Base saturation (Na,K,Ca and Mg) between PR and PT

Fe	**PR**	**17.678±0.584**	**- 1.053**	**0.317**
	PT	29.536±11.245		
Mn	PR	2.025±0.218	- 0.225	0.827
	PT	2.201±0.754		
Cu	PR	0.550±0.095	0.475	0.645
	PT	0.493±0.071		
Zn	PR	0.631±0.111	- 1.804	0.101
	PT	0.980±0.157		
B	PR	2.383±0.337	3.538	0.005
	PT	70.018±0.637		

Base Saturation

The base saturation of both sites showed statistically significant difference between the soil samples ($p<0.05$ is 0.013). The average of mean difference of base saturation of the soil samples revealed that, in the pre-mined area (PR) was 34.085±5.316and post-mined area was 17.898±0.813 (Table.6). The observed results of the base saturation were stated that it was higher in post-mined (PT) area than Pre-mined (PR) area .These variations were occurred due to the increase in tillage practices and most of the exchange sites are occupied by exchangeable cations and low BS were noticed by little ratio between the bases. According to McKenzie, 2015 based on the repeated field trials measured that crop yields against the cation ratios have found that no correlation between cation ratios and yield.

Bacterial Population

The average bacterial population in the study areas were statistically differ significantly ($P<0.05$ is 0.000) and the average mean difference between the sites were observed that in PR (16.45±0.120) and in PT was 19.36±0.120 (Table.7). In this study the result showed that the highest number of bacterial colonies were observed in post-mined (PT) than pre-mined (PR) areas. The variations were found due to the day to day disturbances on soil. The low bacterial population were occurred due to the human interferences and movement of large number of machineries were running through this area than other sites. The similar result were observed in the studies of Jomes,et.al.,2010.stated that long termno-tilled soils have significantly greater level of microbes than conventional tilled soils and the majority of microbes in the exist under starvation conditions and thus they tend to be in dormant state especially in tilled soils.

Table. 7. The data and test of significance for the comparison of mean difference of bacterial populations between PR and PT

Parameter	Sites	Mean ± SE	T	Sig (p value)
Bacterial populations	PR	16.45±0.120	-20.154	0.000
	PT	19.36±0.120		

Correlation studies

Correlation studies of soil physical properties and bacterial populations of PR

From the correlation table (Table.8), the result of the study showed that sand particles showed significantly highly negatively correlated with silt content and clay particles. The silt content showed significantly and highly positively correlated with clay particles and negatively correlated with bulk density. The clay particles showed positively correlated with bulk density. Soil bacterial population showed negative correlation with sand particles, silt content and clay particles.

Table 8. Correlation of physical characteristics and bacterial populations of Pre-mined area (PR)

	Sand	Silt	Clay	BD	MC	BP
Sand	1					
Silt	-.1000**	1				
Clay	-.1000**	1.000**	1			
BD	-.515	0.515	0.515	1		
MC	-.969**	.969**	.969**	0.43	1	
BP	-.092	.092	.092	-.465	-.038	1

Correlation studies of soil chemical properties and bacterial populations of PR

From the correlation table (Table 9) the result of the study showed that electrical conductivity was significantly and highly positively correlated with copper, sodium and magnesium. Organic carbon was significantly and highly correlated with organic matter, available phosphorus, boron and base saturation and highly negatively correlated with available potassium, available sulphur, zinc, cation exchange capacity and magnesium. Organic matter showed significant positive correlation with boron and base saturation and negative correlation with available potassium, available sulphur, zinc, cation exchange capacity and magnesium. Among the available macronutrients, available nitrogen showed positive correlation with iron, copper and sodium. Available phosphorus showed positive correlation with boron and base saturation. Available potassium showed positive correlation with sulphur, zinc, cation exchange capacity, magnesium and negative correlation with boron and base saturation. In available micronutrients, iron showed positive correlation with manganese and sodium. Copper showed positive correlation with sodium and calcium. Zinc showed positive correlation with cation exchange capacity and magnesium and negative correlation with boron and base saturation. Boron showed positive correlation with base saturation and negative correlation with cation exchange capacity .Cation exchange capacity showed positive correlation with magnesium and negative correlation with base saturation. Among the exchangeable bases only magnesium showed negative correlation with base saturation. Soil bacterial population showed negative correlation with available nitrogen and exchangeable potassium..

Correlation studies of soil physical properties and bacterial populations of PT

From the correlation table, the result of the study showed that sand particles showed significantly highly negatively correlated with silt content and clay particles. The silt content showed significantly and highly positively correlated with clay particles and negatively correlated with bulk density. The clay particles showed positively correlated with bulk density. Soil bacterial population showed negative correlation with sand particles, silt content and clay particles (Table .9)..

Table 9. Correlation of physical characteristics and bacterial populations of Post-mined area (PT)

	Sand	Silt	Clay	BD	MC	BP
Sand	1					
Silt	-.999**	1				
Clay	-.1000**	1.000**	1			
BD	.991**	-.988**	.989**	1		
MC	-.029	.012	.014	.107	1	
BP	-.869*	-.869*	-.867*	.790	.320	1

Correlation studies of soil chemical properties and bacterial populations of PT

From the correlation table (Table.11), the result of the study showed that, pH showed positive correlation with sulphur, zinc, potassium and calcium. Electrical conductivity was significantly and fairly positively correlated with magnesium. Organic carbon was significantly and highly correlated with organic matter, available phosphorus, available potassium, available sulphur, iron, manganese, exchangeable potassium, calcium and base saturation and highly negatively correlated with cation exchange capacity. Organic matter showed significant positive correlation with available phosphorus, available potassium, available sulphur, iron, manganese, zinc, exchangeable potassium, calcium and base saturation and highly negatively correlated with cation exchange capacity. Among the available macronutrients, available nitrogen showed positive correlation with available potassium, zinc and exchangeable sodium and potassium. Available phosphorus showed positive correlation with available potassium, available sulphur, iron, manganese, zinc, exchangeable potassium, calcium and base saturation and highly negatively correlated with cation exchange capacity. Available potassium showed positive correlation with available sulphur, iron, manganese, zinc, exchangeable sodium, potassium, calcium and base saturation and highly negatively correlated with cation exchange capacity. Available sulphur showed positive correlation with iron, manganese, zinc, exchangeable sodium, potassium, calcium and base saturation and negatively correlated with cation exchange capacity. In available micronutrients, iron showed positive correlation with manganese, potassium, calcium and base saturation and negatively correlated with cation exchange capacity. Manganese showed positive correlation with zinc exchangeable sodium, potassium, calcium and base saturation and negatively correlated with cation exchange capacity. Zinc showed positive correlation with sodium, potassium and calcium. Boron showed positive correlation with magnesium. Cation exchange capacity showed negative correlation with exchangeable potassium and base saturation. Among the exchangeable bases, sodium showed positive correlation with potassium and potassium showed positive correlation with calcium and base saturation and calcium showed positive correlation with base saturation. Table below showed that soil bacterial population showed negative correlation with sand particles, silt content and clay particles.

Principal Component Analysis

Principal Component Analysis of Pre-mined area (PR)

The communalities of various Physico-chemical parameters were very high indicating that PCA seems to be best in dimensionally reducing the parameters into meaningful components (factors) without sacrificing much information contained in the original data (Table.12). PCA generates three dimensions accounting 96.225% of the total information given by the original data set. The first component (F1) explains 51.881% information of the original data set and it was highly positively loaded with silt (0.985), clay (0.985), sulphur (0.983), potassium (0.974), moisture content (0.972) ,zinc (0.953), cation exchange capacity (0.922), magnesium (0.831) but negatively loaded with organic carbon (-0.992), organic matter (-0.992) ,base saturation (-0.987), sand (-0.985), boron (-0.981) ,phosphorus (-0.837). The second component (F2) explains 25.571% information of the data and it was positively loaded with calcium (0.971) , copper (0.891),electrical conductivity (0.855),sodium (0.814) , bulk density (0.808) and negatively loaded with pH (-0.833). The third component (F3) explains 13.865% information of the and it was highly positively loaded with potassium (0.814), manganese (0.731), nitrogen (0.713) and iron (0.694).

In order to find out the correlation of microbial population with various Physico-chemical factors a multiple linear regression model has been build. The principal components were uncorrelated ,we could use these components were explanatory variables and a regression model can be fitted using microbial population as dependent variable and PCA were independent variables. Therefore using multiple regression analysis were chosen model (MP =16.450* + 0.034 F1 -0.067 -0.179 *). The constructed multiple linear regression model seems to be ideal in finding association of microbial population with Physico – chemical parameters (F = 21.846, p<0.05, adjusted R square 0.926) using t-test for the regression coefficient it was observed that the microbial population was significantly correlated with F3 (0.017) and not significant with F1 (0.288) and F2 (0.108).

Table.10.PCA-Rotational Component Matrix of Pre-Mined areas (PR)

Principal

Parameter	Components		
	1	**2**	**3**
OC	**-.992**	-.120	.016
OM	**-.992**	-.125	.002
BS	**-.987**	-.105	.108
SILT	**.985**	.165	.029
SAND	**-.985**	-.165	-.029
CLAY	**.985**	.165	.029
S	**.983**	.174	.051
B	**-.981**	.046	.170
K	**.974**	.206	.094
MC	**.972**	.038	.217
Zn	**.953**	.254	.165
CEC	**.922**	.345	.175
P	**-.837**	.219	.500
Mg	**.831**	.481	.275
Ca	-.025	**.971**	-.044
Cu	.072	**.891**	.406
EC	.422	**.855**	.264
pH	-.249	**-.833**	-.090
Na	-.085	**.819**	.567
BD	.369	**.808**	.297
K	-.314	.223	**.814**
Mn	.496	.346	**.731**
N	.054	.681	**.713**
Fe	.267	.598	**.694**
% VARIANCE	**56.818**	**25.571**	**13.865**
%CUMILATIVE VARIENCE	**56.818**	**82.390**	**96.255**

Component Analysis of Post-mined area (PT)

The communalities of various physico-chemical parameters were very high indicating that PCA seems to be best in dimensionally reducing the parameters into meaningful components (factors) without sacrificing much information contained in the original data (Table.13). Here PCA generates three dimensions accounting 95.643% of the total information given by the original data set. The first component (F1) explains 67.790% information of the original data set and it was highly positively loaded with base saturation (0.975), calcium (0.973), silt (0.972), iron (0.972), organic carbon (0.971), clay (0.971) organic matter (0.969) phosphorus (0.960), sulphur (0.941), manganese (0.897) available potassium (0.887),exchangeable potassium (0.861),pH (0.836), ,zinc (0.780), sodium (0.678) but negatively loaded with sand (-0.968) ,bulk density (-0.952), boron (-0.736) ,cation exchange capacity (-0.708). The second component (F2) explains 14.827% information of the data and it was positively loaded with electrical conductivity (0.943), magnesium (0.854) , copper (0.825) .The third component (F3) explains 13.027% information of the and it was positively loaded with nitrogen (0.780) and negatively loaded with moisture content (-0.803).

The correlation of microbial population with various physico-chemical factors, a multiple linear regression model has been build. The principal components were highly correlated with other ,we could use these components were explanatory variables and a regression model can be fitted using microbial population as dependent variable and PCA were independent variables .Therefore using multiple regression analysis were chosen model (MP =19.367* - 0.263 F1 -0.072 -0.106 *). The constructed multiple linear regression model seems to be ideal in finding association of microbial population with physico –chemical parameters (F = 63.378,

$p<0.05$, adjusted R square 0.974) using t-test for the regression coefficient it was observed that the microbial population was significantly correlated with F1 (0.006) and F3 (0.038) and not significant with F2 (0.076).

Table.11. PCA-Rotational Component Matrix of Post-Mined areas (PT)

Parameter	Components		
	1	2	3
BS	**.975**	-.177	.131
Ca	**.973**	.132	.184
SILT	**.972**	-.197	.124
Fe	**.971**	-.190	.141
OC	**.971**	-.184	.148
CLAY	**.971**	-.201	.123
OM	**.969**	-.182	.166
SAND	**-.968**	.222	-.118
P	**.960**	-.132	.244
BD	**-.952**	.299	-.016
S	**.941**	.070	.326
Mn	**.897**	-.291	.303
K	**.887**	-.088	.450
K	**.861**	.090	.471
pH	**.836**	.351	.219
Zn	**.780**	.179	.595
B	**-.736**	.624	.222
CEC	**-.708**	.407	-.485
Na	**.678**	-.059	.548
EC	-.170	**.943**	.014
Mg	-.500	**.854**	.071
Cu	.532	**.825**	.184
MC	.088	-.227	**-.803**
N	.549	-.022	**.780**
% VARIANCE	**67.790**	**14.827**	**13.027**
%CUMILATIVE VARIENCE	**67.790**	**82.616**	**95.643**

According to Singh et.al. 2013 reported that the types of soil and land use practices were responsible for the varying soil inherent properties based on correlation studies. The differentiation level of soil functions in the different land use types were depend upon the reclamation process varying structural as well as stochastic factors of soil and this was identical with e result of yang and Yao.,2009. The correlation coefficient between the soil Physico -chemical properties with bacterial count showed no significant correlation was reported by Mohammad ,et.al.,2012 .The studies of Sun Yongguagg, et.al.,2011 stated that the comprehensive evaluation index of soil functions constructed by PCA can better reflect the soil level ,land use types, quantitative relationship between soil differentiation . The information reflected by the PCA method may affected by the indices selected.

Conclusion

From the findings of the study, it concluded that the physico-chemical characteristics and the microbial populations of the of the study area revealed that both sites of the study areas were close to each other. The environmental conditions such as climatic and topographic factors. Among these parameters , the t-test showed N,MC,B,CEC and B was significant difference between the sites and many of the characteristics were positively correlated with each other and the bacterial count were recorded as the mean difference between the sites are 16.45±0.12 in PR and 19.36±0.12 in PT. The quantification of bacteria revealed that there was significant difference between the sites. The PCA were conducted by considering all the physico-chemical characteristics were taken as independent variables and microbial populations were dependent variables. Here all the components were categorised into three factors (F1-F3). In site PR, the F1 and F3 were positively correlated with microbial populations and in PT, F1 were positively loaded with the microbial populations. So some of the properties were significantly related. Mining activities resulting the disruption of overall quality of soil ecosystem. It replaces the existing system and disrupts the natural compactness of the soil. So the restoration of mined land should be necessary for the conservation our natural resources and essential for the ecological processes.

References

Aswathanarayana, U. (2003). Natural resources and environment. Geological Society of India, Bangalore, India. pp. 58-59.

Awdenegest Moges,Melku Dagnachew, and Fantaw Yimer. (2013) Land use effects on soil quality indicators: a case study of abo-wonsho southern ethiopia Hindawi Publishing Corporation,*Applied and Environmental Soil Science*,pp.1-9.

Bhaskar BP, Butte PS and Utpal Brauah S (2005). Charecterization of soils in the 'Bil'environs of Brahmaputra vally in Jorhat district, Assam for landuse interpretation: *Journal of Indian Society of Soil Science* **53**:pp 3-10.

Table. 11.Correlation studies of soil chemical properties of PR

	pH	EC	OC	OM	N	P	K	S	Fe	Mn	Cu	Zn	B	CEC	Na	K	Ca	Mg	BS	BP
pH	1																			
EC	-0.807	1																		
OC	0.329	-0.518	1																	
OM	0.339	-0.525	1.000**	1																
N	-0.682	0.806	-0.12	-0.134	1															
P	-0.031	-0.031	.813*	0.805	0.467	1														
K	-0.412	0.613	-.990**	-.992**	0.258	-0.724	1													
S	-0.383	0.577	-.996**	-.997**	0.205	-0.76	.999**	1												
Fe	-0.756	0.807	-0.316	-0.33	.956**	0.265	0.442	0.395	1											
Mn	-0.594	0.656	-0.516	-0.531	0.775	0.025	0.62	0.582	.882*	1										
Cu	-0.724	.925**	-0.176	-0.185	.905*	0.338	0.295	0.249	0.81	0.583	1									
Zn	-0.465	0.659	-.973**	-.977**	0.339	-0.661	.996**	.990**	0.518	0.687	0.359	1								
B	0.152	-0.337	.973**	.969**	0.104	.918**	-.931**	-.950**	-0.097	-0.326	0.026	-.895*	1							
CEC	-0.526	0.73	-.954**	-.958**	0.408	-0.609	.986**	.976**	0.569	0.703	0.447	.995**	-.860*	1						
Na	-0.709	.818*	-0.004	-0.016	.961**	0.535	0.139	0.087	.863*	0.648	.958**	0.219	0.217	0.303	1					
K	0.013	0.28	0.284	0.273	0.663	0.702	-0.173	-0.217	0.485	0.455	0.549	-0.106	0.426	-0.063	0.668	1				
Ca	-0.727	0.794	-0.099	-0.103	0.592	0.201	0.176	0.148	0.478	0.294	.846*	0.219	0.052	0.308	0.767	0.278	1			
Mg	-0.635	.840*	-.877*	-.883*	0.575	-0.451	.934**	.914*	0.708	0.773	0.605	.958**	-0.747	.980**	0.48	0.061	0.426	1		
BS	0.302	-0.482	.995**	.994**	-0.046	.858*	-.974**	-.984**	-0.242	-0.434	-0.129	-.949**	.986**	-.928**	0.059	0.359	-0.086	-.842*	1	
MP	862**	-0.431	.958**	.934**	.861*	.818*	0.016	0.067	-0.8	-0.749	-0.626	-0.073	-0.352	-0.114	-0.802	-.843*	-0.298	-0.263	-0.242	1

**	Correlation is significant at the 0.01 level (2-tailed)
*	Correlation is significant at the 0.05 level (2-tailed).

Table.12. Correlation studies of soil chemical properties of PT

	pH	EC	OC	OM	N	P	K	S	Fe	Mn	Cu	Zn	B	CEC	Na	K	Ca	Mg	BS	BP
pH	1																			
EC	0.161	1																		
OC	0.788	-0.344	1																	
OM	0.792	-0.339	1.000**	1																
N	0.522	-0.047	0.644	0.656	1															
P	0.809	-0.296	.993**	.995**	0.715	1														
K	0.799	-0.063	.887*	.892*	.871*	.933**	1													
S	.877*	-0.103	.950**	.953**	0.767	.976**	.977**	1												
Fe	0.78	-0.35	1.000**	.999**	0.641	.993**	.885*	.947**	1											
Mn	0.675	-0.436	.969**	.970**	0.755	.977**	.912*	.929**	.970**	1										
Cu	0.78	0.673	0.393	0.397	0.407	0.448	0.621	0.621	0.387	0.296	1									
Zn	.823*	0.061	0.81	.820*	.910*	.868*	.974**	.939**	0.806	.831*	0.668	1								
B	-0.394	0.711	-0.799	-0.793	-0.217	-0.733	-0.45	-0.571	-0.803	-0.756	0.165	-0.325	1							
CEC	-0.635	0.457	-.835*	-.844*	-0.74	-.842*	-0.751	-0.779	-.830*	-.858*	-0.12	-0.763	0.709	1						
Na	0.491	-0.131	0.74	0.745	.930**	0.794	.913*	.821*	0.742	.846*	0.408	.873*	-0.35	-0.653	1					
K	.824*	-0.219	.944**	.951**	.833*	.971**	.958**	.972**	.941**	.950**	0.48	.943**	-0.616	-.900*	.831*	1				
Ca	.894*	-0.025	.947**	.948**	0.685	.959**	.936**	.982**	.945**	.888*	0.657	.895*	-0.593	-0.729	0.759	.935**	1			
Mg	-0.097	.857*	-0.63	-0.626	-0.256	-0.571	-0.313	-0.38	-0.635	-0.667	0.459	-0.2	.922**	0.691	-0.352	-0.491	-0.366	1		
BS	0.791	-0.341	1.000**	.999**	0.63	.992**	.883*	.948**	1.000**	.965**	0.398	0.803	-0.801	-.825*	0.73	.939**	.947**	-0.625	1	
BP	.949**	-.072	.879*	.884*	.846*	.914*	-.947**	-.975**	-.874*	-.830*	-.747	-.948**	.438	.727	-.740	--.937**	-.966**	.208	-.879*	1

**	Correlation is significant at the 0.01 level (2-tailed).
*	Correlation is significant at the 0.05 level (2-tailed).

Bossuyt,H.,K. Denef, J. Six,S.D. Frey, R. Merckx, and K. Paustian. (2001). "Influenceof microbial populations and residue quality on aggregate stability." *Applied Soil Ecology* **16**: pp195-208.

Cappuccino, J.G and , N. (2008). *Microbiology: a laboratory manual* (Vol.Boston, MA: Pearson/Benjamin Cummings.

Chakraborty,P.K.(2000).Environment in underground coal mines (mine gases, climate, dust, noise), 2nd Edn, CMPDI Ltd, Ranchi, India. pp. 1-107.

Chenu,C.and Stotzky,G. (2002).Interactions between Microorganisms and Soil Particles: An Overview,Chichester, England, John Wiley & Sons. pp3-40.

Dutta, M. and Ram, M.(1993).status of micronutrientin some soil series of Tripura. *J. Ind. Soc.Soil Sci.***41**(4):pp 776-777.

Ghose, M.K.: Effect of opencast mining on soil fertility. *J. Scien. Indus. Res,* **63**, 1006-1009 (2004).

Ghulam Jeelani Dahar, Parwaiz Ahmed Baloch and Bashir Ahmed Abro. (2014). Distribution of micronutrients in different soil series around tando jam, Sindh, PakistanSci. Tech. and Dev. **33** (1):pp 7-13.

Grundmann,G. L., and Debouzie D. (2000). "Geostatistical analysis of the distribution of NH4 and NO2-oxidizing bacteria and serotypes at the millimeter scale along a soil transect." FEMS, *Microbiology Ecology* **34**: pp 57-62.

Heijnen,C.E.,Chenu,C.and Robert,M.(1993)."Micro-morphological studies on clayamended and unamended loamy sand, relating survival of introduced bacteria and soil structure." *Geoderma* **56**: pp195-207.

Jain, R., Srivastava, S., Solomon, S., Shrivastava, A.K. and Chandra,A. (2010). Impact of excess zinc on growth parameters, cell division, nutrient accumulation, photosynthetic pigments and oxidative stress of sugarcane (Saccharumspp.). *Acta Physiol. Plant*, **32**:pp 979-986.

Kavinpoor,H.,Esmali Ouri,Z., Jafarian Jeloudar,A. and Kavian, A.(2012).Spacial variability of some physical and chemical in Nesho Mountanous Range lands.*American. Jrl. of .Environ. Engg*,**2(1):**pp 34-44.

Kundu, N.K. and Ghose M.K, (1994). Studies on the topsoil of an opencast coal mine. *Environ. Conserv*, **21**, pp 126-132.

McKenzie, R. (2015). *Using Base-Cation Saturation Ratios.* Grainews.

Osman,K.T.(2012).Soils:Principles, properties and management. Springer-NewYork.pp.271.

Raj .K.Shrestha. and RattanLal ,(2011). Changes in physical and chemical properties of soil after surface mining and reclamation.*Geoderma* ,**161**.3-4.pp 168-176.

Ray, R.,Mukhopadhyyay,K. and Biswas,P.(2006).Soil aggregation and its relationship with physico-chemical properies under various land use system.*Indian.J.Soil.Cons*, **34**: pp 28-32.

Sadeghi, S.H.R.,Vangah ,B.G. and Safaeelan ,N.A.(2007). Comparison between the effects of open grazing and manual harvesting of cultivated summer Range lands of Northern Iran on Infiltration,runoff and sediment yield. *Land degradation and Development.* **18** :pp 608-620.

Singh ,P.K.,and Hage Munth.(2013).Comparitive study of physico-chemical, nutrients availability acidic properties of Arunachal Pradesh soil under different land use systems. *Asian J.Soil.Sci*,**8 (2):** pp 457-462.

Singh B., K.N. Sharma.(2007). Tree growth and nutrient status of soil in poplar (Populus Bartr.) – based agroforestry system in Punjab, India. – *Agroforest System*, **70**:pp 125-134.

Singh,V. and Singh,T.N. (2004). Environmental impact due to surface mining in India. Minetech, **25**, pp 3-7.

Sun Yongguang,Li Xiuzhen,Ülo Mander, He Yanlong,Jia Yue, Ma Zhigang,Guo Wenyong, Xin Zaijun. (2011) Effect of reclamation time and land use on soil properties in changing river estuary, china. *Chin. Geogra. Sci.* **21**(4): pp 403–416

Unni,K.S and Fole A. (1999). Surface and ground water quality in coal mine area of Chhindwara dist, Madhya Pradesh. In: Environmental Management in Coal Mining and Thermal Power Plants (Eds.: P.C. Mishra and A. Naik),Technoscience Publications, Bihar, India. pp 197-201.

Weindorf, D.C. and Zhu,Y.(2010).Spacial Variability of soil properties at Capulin volcano,New Mexico,USA: Implications for sampling strategy.*Pedosphere*, **20 (2)**:pp185-197.

Yang Jinsong, Yao Rongjiang. (2009). Evaluation of soil quality in reclaimed coastal regions in North Jiangsu Province.*ChineseJournal of Eco-Agriculture*, **17**(3): pp 410–415.