Influence Of Long-Term Lignite Mines Water Irrigation on Soil and Its Characteristics of Bhuvanagiri Block, Cuddalore District

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Abstract- Mining for lignite was established in 1956 at Neyveli, Cuddalore District. Mine wastewater is used for irrigation of agricultural land of the Bhuvanagiri block. The Mines wastewater pumped out from open cast mines are detained in Walajah Tank for settlement and distributed for Irrigation purpose and compensating of the water shortage. This study shows that wastewater for short term irrigation does not cause pollution to either soil environment or the crops nor will it cause the accumulation of pollutants. Nevertheless, long-term irrigation with wastewater has led to emergence of several steady changes in soil properties, and pollutants level in soils, which consequently affect the soil quality. The influence of mine wastewater on soil depends on different aspects, for instance the source of treatments applied on the wastewater inherent the soil properties. By exploring the effects of mining wastewater in the soil characteristics and crop system in different locations were found by the study. The objectives is to analyse soil and water samples collected randomly from distinct places along where mine field water are being the parts of Bhuvanagiri block. This is an attempt to assess the present status of soil and water to evaluate, if they satisfy the Permissible standards for an Irrigation command area.

Indexed Terms- Mines Wastewater, Crop rotation, Soil Fertility, Irrigation Command Area

I. INTRODUCTION

Water quality is essential to human health, economic and social development and the ecosystem. However due to population explosion and urbanization, degradation of natural environment and water is increasing. Only there are few sufficient and safe water supplies for everyone which becomes increasingly challenging. Also, volume of wastewater generated and its overall pollution is increasing globally. The solution is to produce find ways to reduce pollution and improve wastewater management techniques.

For a sustainable economy we need to quantify the wastewater for its potential value, rather than ignoring it. Safe wastewater management could help protect our ecosystems and give us energy, nutrients and other recoverable materials as an alternative source of water which can support industrial development and sustainable agriculture.

1.1 Wastewater in agriculture

To help maximise yield and to meet demand, usage of pesticides and chemical fertilizers has increased in the recent years in industrial and small farming, making agriculture a potential risk of environmental pollution. Pollution of ground and surface water by use of untreated or inadequately treated wastewater for agriculture is a major issue in many developing countries where such irrigation is practised. The agricultural workers can reduce the risk of pathogenic exposure by improved wastewater management.

Farmers are looking into non-conventional water resources such as wastewater, but due to its high nutrient content their direct application is not safe. Although wastewater maybe a valuable source of both water and nutrients, contributing to water and food security and livelihood improvements.

II. OBJECTIVE OF THE STUDY

- To analyse the physicochemical properties of the soil in the study area.

III. STUDY AREA DESCRIPTION

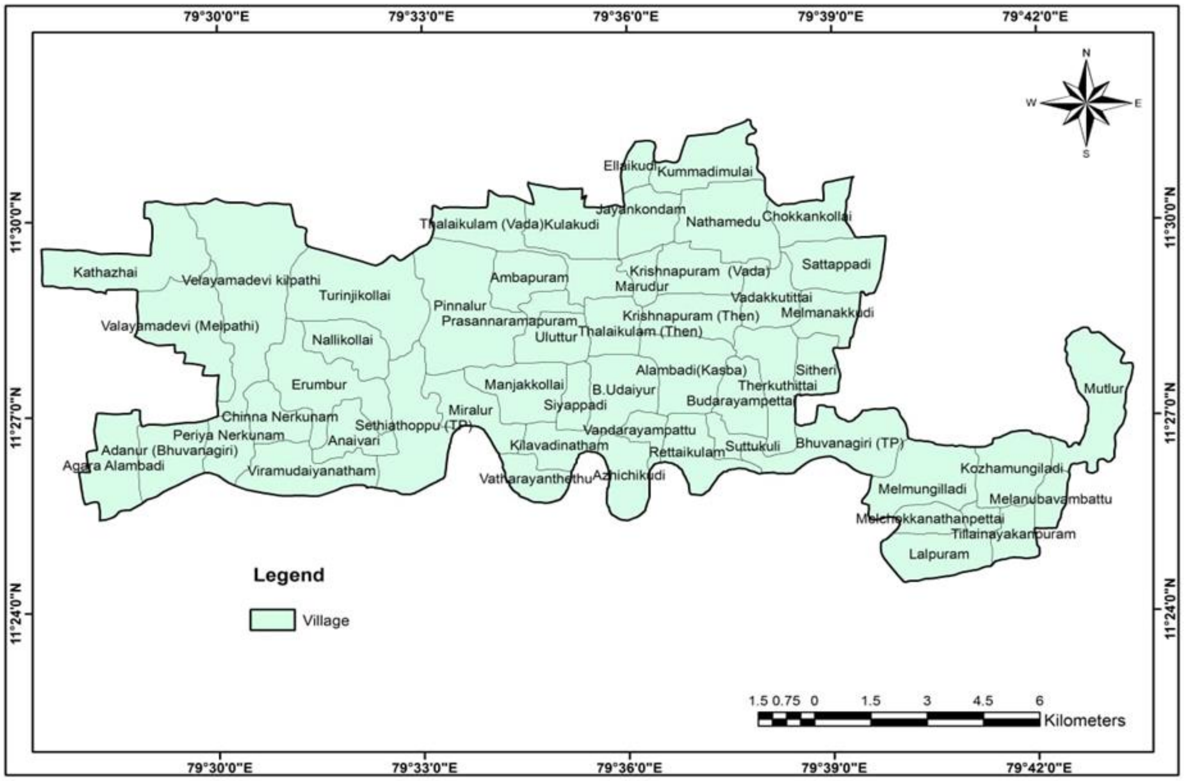

Figure 1. Study Area Map of Bhuvanagiri Block

3.1 Location

The Bhuvanagiri block is situated in between 11º 24′00″ and 11º 30′00″ latitude, 79º 27′00″ and 79º 45′00″ longitude at an altitude of 1.5m above Mean Sea level.

3.2 Catchments and command area

The tank receives water from a catchments of 74 square miles and combined catchments of 216 square miles. It receives water from Cauvery basin and Vellar river basin from Sethiathope weir through the stream Paravanar. The total area of the Walajah tank command is 6503 acres. The entire command area is irrigated through 11 canals.

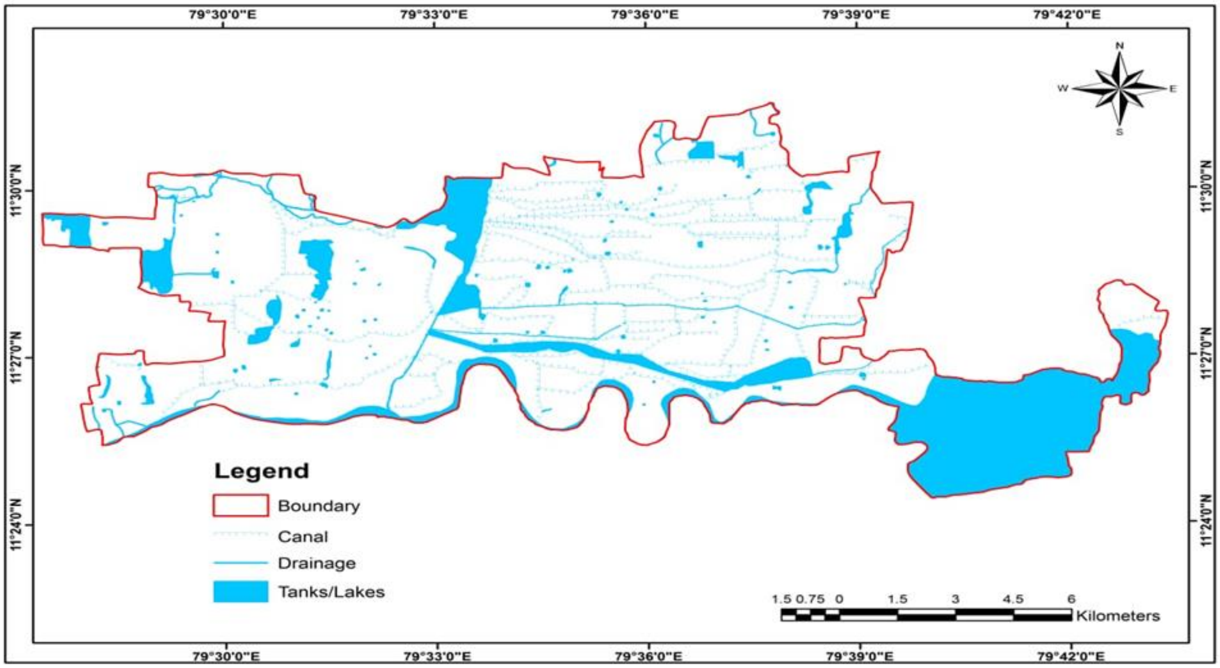

Figure 2. Drainage Map of Bhuvanagiri Block

3.3 Climate

The climate of the area is monsoon type with an average annual rainfall of 1284mm mostly during the North-East monsoon period of October-December. The relative humidity is less during the hot month and more during the cold month. It ranges from 58 percent in May to 81 percent in December. Wind speeds are mild ranging from 5 km / h in the month of March, 12 km / h in month of June. Average number of hours of bright sunshine per day is about 8 and the average rainfall of Walajah tank command area is 1346.66 mm. These data pertain to the Indian Metrological Department Observatory located at Annamalai University, Annamalai Nagar, which is the nearest weather station to study area.

3.4 Cropping Pattern

Paddy is the principle crop grown in commanded area of Walajah tank as the Ryots of the command of Walajah tank systems are blessed with continuous availability of water in from of mine drainage from Neyveli, they raised two crop in the tank irrigated commands, the first crop (Kuruvai) of paddy is usually grown in June/July to September/ October while the second (Navarai) in the command of Walajah tank is also a medium variety of baddy grown during December/ January to March/ April whereas black gram and green gram are the other crops cultivated as follows:

1. Paddy – Paddy
2. Paddy – Paddy – Black gram

3.5 Rainfall

The average annual rainfall in the Walajah tank command area is 1346.6 mm. About 90% of the annual rainfall is received during North-east monsoon period. The productivity of the monsoon crop in the command area depends mainly on the success of the North-east monsoon. In the absence of sufficient rainfall during the monsoon period, water availability for irrigation is augmented by the mines drainage reaching the tank almost continuously throughout the year. This continuous receipt of mine drainage by the tank enables irrigating crops grown during the non-monsoon period.

3.6 Soil texture

The soil in the Walajah tank command area is generally clayey and, in some regions, it is sand mixed clay alluvium.

3.7 Salient Features of Walajah Tank: NWM (National Water Mission, 2017)

Walajah tank is the first major tank which lies at the end of Upper reaches of Paravanar basin. It is a system tank as it also receives water from Sethiathope anicut, the last anicut across Vellar River through VellarRajan channel. When there is higher demand, a discharge upto 28 cumec could be drawn through VellarRajan Channel by increasing the depth of flow by 0.30m above the normal full supply depth. After feeding a direct ayacut of 12,222 ha through nine branch channels, it empties into Walajah tank. In the command area of Walajah tank there are 8 minor tanks, which act as buffer storage to irrigate the lands under Walajahtank. But at present there is no flow from Vellar Rajan Channel to Walajah tank. The major input to the tank is the pumping water from NLC mine II. There are 11 channels taking off from the tank sluices to feed the command area of 4612 Ha.

IV. METHODOLOGY

Soil sample processing procedure in field: (TNAU, 2013)

- Soils vary from place to place, take the samples in homogeneous way that it is fully representative of the field based on visual observation and farmer's expertise.
- Remove surface litter, stones, pebbles, roots and other foreign materials surface on the sampling

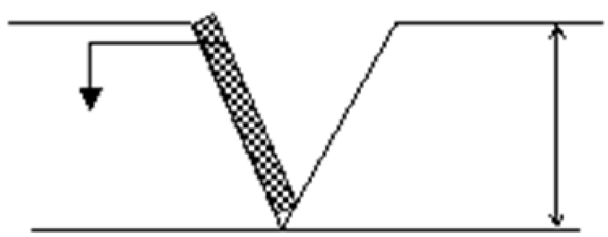

Figure 3. Soil sample excavation aspects

- Using a spade to make a 'V' shaped cut at a depth of 15cm and a breadth of 2.5cm.
- Collect atleast 10 samples from a sampling unit and mix it thoroughly then remove gravel, stones, and plant fibres from the sample.
- Reduce the bulk of samples by uniform compartmentalization until required sample size is obtained.
- Collect the sample in a polythene bag and is sealed properly to avoid exposure.
- Label the bag with information like name of the farmer, location of the farm, survey number, previous crop grown, present crop, crop to be grown in the next season, date of collection name of the sampler.

4.1 Processing and storage of soil samples:(Water Resources Department, Pune, 2009)

1. The collected soil samples are homogeneously mixed, left to attain equilibrium with air for 2 hours in the trays / paper dishes.
2. If the samples are dry enough it can be taken for further testing without treating in the oven.
3. If the soil samples are wet then samples are dried in the oven at 25^0C for 2 hours or more (depending upon the wetness of the sample). If samples found sticky even after drying, then the temperature may be raised by 2 to 5^0C, but in any case, it should not exceed 35^0C.
4. After drying the clods in soil are crushed gently and grounded with the help of wooden pestle and mortar. Gravel, soft chalk, limestone, stones and other concretions should be removed from the samples.
5. The soil samples are passed through 2.0 mm and 0.5 mm sieve individually. The sufficient quantity of sieved soil sample is kept in plastic bag labelled along with the sieve size 2.0 mm / 0.5 mm.
6. The plant residues, gravel, and other materials retained on the sieve may be discarded.

4.2. Soil Testing Parameters:

Soil testing refers to the chemical analysis of soils and is well recognized as a scientific means for quick characterization of the fertility status of soils and predicting the nutrient requirement of crops.

4.2.1. Texture of soil. The process of determining the amount of individual size separates of soil below 2 mm in diameter i.e. sand, silt and clay called particle size analysis. Particle size distribution has an important influence on soil permeability or water intake rate, water storage capacity ability to aggregate, crushing and the chemical makeup of the soil. The value of land, land use capability and soil management practices are largely determined by the texture.

4.2.2. pH in soil. The determination of pH in soil is important as it plays a great role in availability of nutrients to plants. This determination can be done more accurately in the laboratory by electrometric

method. pH determination is useful for soil classification on the basis of Acidity or alkalinity.
Testing principle for pH. The electrometric determination of pH by a pH meter is based on measuring the e.m.f. (millivolts) of a pH cell both a reference buffer and then with a test solution. The change in the potential difference at 25^0C for 1 pH unit is 59.1 mV. The pH of a soil is a measure of the hydrogen or hydroxyl ion activity of the soil – water system. It indicated whether the soil is acidic, neutral or alkaline in reaction.

4.2.3. Electrical Conductivity (EC) in soil. Salted soils are classified on the basis of two criteria, one is on the basis of total soluble salt (TSS) content and another is exchangeable sodium percentage (ESP) or more recently sodium Absorption ration (SAR). Ions in water conduct electrical current, therefore electrical conductivity is fast, simple method of estimating amount of total soluble salt (TSS) in soil sample. Electrical conductivity is expressed in dS/m.

Testing principle for EC. The electrical conductivity of water extract of soil gives a measure of soluble salt content of the soil. Pure water is very poor conductor of electric current, whereas water containing the dissolved salts in soil conducts current approximately in proportion to the amount of soluble salts present. The conductivity of the soil is the specific conductivity at 25^0C of water extract obtained from a soil and water mixture of 20gm: 50ml ratio.

4.2.4. Calcium Carbonate content in soil. Alkaline earth carbonates in soils consist of calcite, dolomite and possibly magnesite and occur commonly in the silt size fraction. These influence the texture of the soil when present in appreciable amounts. These are important constituents of alkali soils, they constitute a potential source of calcium and magnesium. Lime aids in preserving soil structure and may serve as a source of calcium in the reclamation of alkali soil.

*Testing principle for $CaCO_3$.*Soil is treated with an excess of standard hydrochloric acid, destroying carbonates. The amount of excess acid is determined by titration with standard sodium hydroxide, after separation from the soil by filtration or centrifugation. The acid dissolves a certain amount of soil materials and these metals are precipitated as hydroxides when the pH rises towards the end of the filtration with alkali. The amount of acid destroyed in dissolving the metals is equivalent to the amount of alkali used to precipitate their hydroxides.

4.2.5. Total Nitrogen content in soil. Soil nitrogen occurs largely in the organic form (97-99%). The availability of N is associated with the activity of micro-organisms which develops the organic matter (NH_4-N and NO_3-N). The nitrification rate of a soil is measure of the rate of release of available nitrogen from the organic matter in the soil. A discrete fraction of the soil organic nitrogen is attacked by KMnO4and that this fraction was most readily susceptible to biological mineralization.

Testing principle for Total Nitrogen. The organic matter in the soil is oxidized by $KMnO_4$ in presence of NaOH. The ammonia released during oxidation is absorbed in boric acid to convert the ammonia to ammonium borate. The ammoniumborate formed is titrated with standard H_2SO_4. From the volume of standard H_2SO_4 required for the reaction with ammonium borate, the N is calculated.

4.2.6. Phosphorous content in soil. Phosphorous is most critical essential element nest to nitrogen in influencing plant growth & production throughout the world. Phosphorous has an important effect on functions & qualities of plants such as Photosynthesis, Nitrogen fixation, Crop maturation, Root development and Protein synthesis. It is determined by Olsen's Method.
Testing principle for Phosphorous. Under neutral to alkaline soil conditions, Olsen's P (0.5 M $NaHCO_3$solution at pH 8.5) is the most widely used extract for estimation of available phosphorous in soil. In this process the most effective form of "P" is extracted from the phosphates of Fe, Al and Ca present in different type of soils. The extracted phosphorous is measured calorimetrically.

4.2.7. Potassium content in soil. Next to nitrogen and phosphorous, potassium is the most critical essential element in influencing plant growth and production throughout the world. Potassium plays essential role in plants. It is an activator for dozens of enzymes responsible for plant photosynthesis, protein synthesis, starch formation and translocation of sugars. Also, it exerts a balancing effect on both nitrogen and phosphorous.

Testing principle for Potassium. When a solution of the metallic salt is atomized into a non-luminous flame, electrical K atoms get excited and emit light when come to ground state. The light emitted is filtered through a glass filter which allows light to definite wavelength of that element, 766.5 nm for K, to pass. The light falls on photocell emitting electrons generating an electric current. This current is measured on the galvanometer and is proportional to the concentration of metal element present in solution atomized.

4.2.8. Iron content in soil. The concentration of iron ions is important part in the oxidation process of leaf cells. Iron deficiency manifests in chlorosis, yellowing or whitening of leaves and eventual leaf loss. When iron is not taken up in adequate quantity, the growth of plants is less vigorous, and seed and fruit development suffer as a consequence of decreased photosynthetic activity in the leaves.

4.2.9. Manganese Content in soil. Manganese is an essential element and appears to have a role in the formation or synthesis of chlorophyll. Due to deficiency of manganese the carbohydrate synthesis is disturbed, resulting in retarded growth, decrease in the content of ash and failure to reproduce. The leaves and roots of Manganese deficient plants have much less of sugars than those which can absorb sufficient quantity of manganese. Manganese, probably in association with iron, is a constituent of some respiratory enzymes and some enzymes responsible for protein synthesis from the amino acids formed in the leaves.

4.2.10. Zinc content in soil. A high content of zinc is correlated with a high amount of chlorophyll. In its absence growth is less, buds fall off and seed development is limited. In some crops zinc deficiency symptoms are manifested in leaf. In small trees bronzing of leaves is mitigated by spraying zinc sulphate on leaves. The mottling of leaves may be frequently due to the deficiency of zinc in the plant.

4.2.11. Copper content in soil. In the chloroplasts of leaves there is an enzyme NADP which is concerned with the oxidation-reduction processes. The presence of copper is essential for this enzyme to function. Thus, copper plays an important role in the process of photosynthesis. Crops affected with chlorosis, doesn't recover if copper sulphate is not applied to soil soon.

4.2.12. Testing principle for micronutrients. For all the micronutrients effective way to analyse the extractable quantity is Atomic Absorption Spectrophotometry (AAS). AAS can be successfully applied for estimation of Zn, Cu, Fe and Mn. For specific estimation on AAS, hollow cathode lamps, specific to specific elements are used.

The procedure is based on flame absorption because metal atoms absorb strongly at discrete characteristic wavelengths which coincides with the emission spectral lines of a particular element. The liquid sample is atomized. The hollow cathode lamp which precedes the atomiser, emits the spectrum of the metal used to make the cathode. This beam traverse the flame and is focused on the entrance slit of a monochromator, which is set to read the intensity of the chosen spectral line. Light with this wavelength is absorbed by the metal in the flame and the degree of absorption being the function of the concentration of the metal in the flame, the concentration of the atoms in the dissolved material is determined. For elemental analysis, a working curve or a standard curve is prepared by measuring the signal or absorbance of a series of standards of known concentration of the element under estimation. From such curve, concentration of the element in unknown sample is estimated.

V. RESULT AND DISCUSSION

The table-1 shows the analysed result of physical properties, available quantity of Macronutrients and micronutrients for the collected soil samples.

5.1. Soil texture. The soil type distributed among Bhuvanagiri block is majorly Vertisol.

5.2. Calcium Carbonate ($CaCO_3$). The samples collected from Alambadi and Kalakudi shows 10-15% of CaCO3 level which ranges very high thus it requires sub-soil drainage. Samples collected from other sites showed very negligible presence of $CaCO_3$.

5.3. Electrical Conductivity (EC). The samples from Marudur, Sattappadi, Thalaikulam have soluble salt levels below 1dS.m^{-1} which shows characteristics for good soil. Soil samples collected from other sites shows TSS level slightly higher which can result in poor seed emergence.

5.4. pH. Soil from Krishnapuram has neutral pH and Soil from Sattappadi is moderately Alkaline. The samples from other sites are slightly alkaline thus it need to be treated with acidic nitrogen, organic mulch to reduce alkalinity.

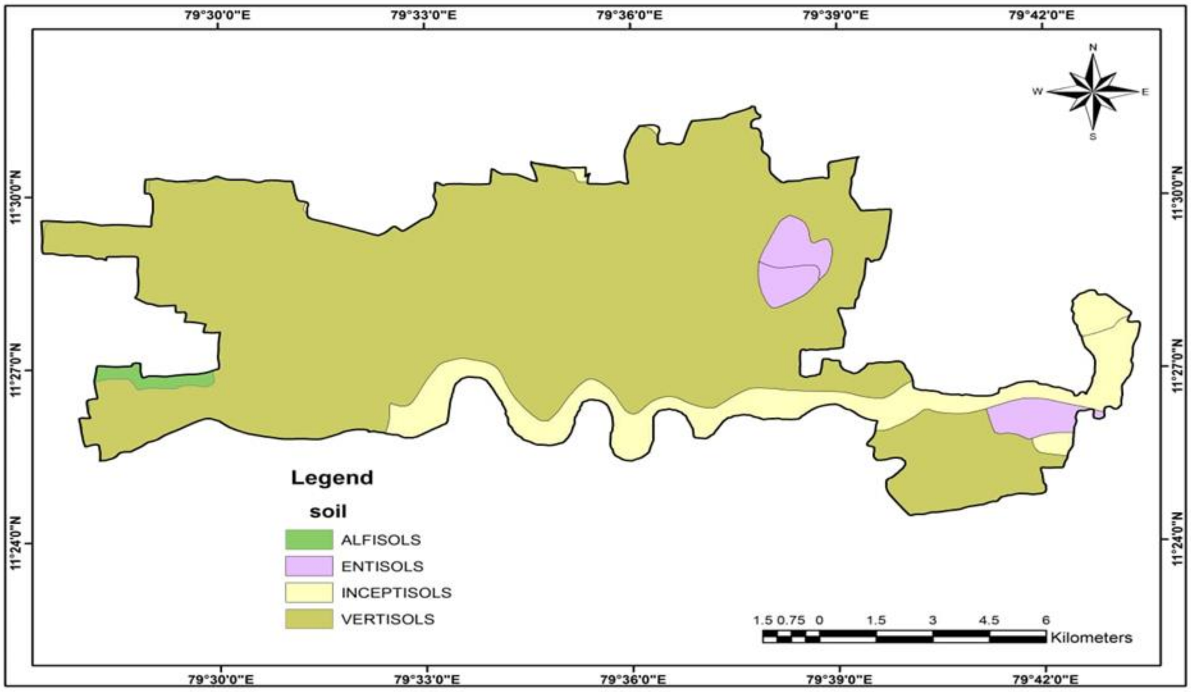

Figure 2. Spatial Distribution of soil-Bhuvanagiri Block

Table 1. Physico chemical Analysis of Soil samples.

Samples/ Properties	Krishnapuram (Sample 1)	Alambadi (Sample 2)	Marudur (Sample 3)	Kulakudi (Sample 4)	Nathamedu(Sample 5)	Kothavacheri (Sample 6)	Sattappadi(Sample 7)	Thalaikulam (Sample 8)
PhysicalProperties								
Soil Texture	Vertisol Soil	Vertisol Soil	Vertisol Soil	Vertisol Soil	Vertisol Soil	Vertisol Soil	Vertisol Soil	Vertisol Soil
CaCO3 (%)	Nil	10-15	Nil	10-15	Nil	Nil	Nil	Nil
EC (dS/m)	1.20	1.21	0.39	1.20	1.30	1.23	0.92	0.78
pH	6.8	7.3	7.2	7.1	7.3	7.2	7.6	7.5
Macronutrients								
N (Kg/ha)	46	48	31	49	42	57	43	39
P (Kg/ha)	12	5	6	5	8	5	5	8

K(Kg/ha)	110	85	57	70	60	110	147	100
Micronutrients								
Fe (ppm)	18.42	17.89	18.90	16.82	17.05	18.41	19.02	18.22
Mn (ppm)	8.92	8.33	8.55	9.11	7.82	7.49	6.84	7.11
Zn (ppm)	1.05	1.17	0.99	1.11	1.21	1.15	1.05	1.10
Cu (ppm)	1.29	1.23	1.42	1.22	1.25	1.18	1.30	1.33

5.5. Nitrogen. The soil samples collected from all the sites ranges below 140Kg/ha of Nitrogen content which falls under very low level. The crops may show stunted growth because they cannot produce the proteins and amino acids, so sooner it should be treated by nitrogen fixation or nitrogen can be recycled by composting plants and manure.

5.6. Phosphorous. The soil samples taken from Krishnapuram, Nathamedu, Thalaikulam show low presence of phosphorous while samples taken from other sites show very low presence of phosphorous. The crops may show reduced growth and yield, delayed maturity. To increase phosphorous content treat the soil with scattered bone meal, rock phosphate and phosphate fertilizer.

*5.7. Potassium.*The sample collected form Sattappadi shows 147Kg/ha which falls under low levels of Potassium. The samples from other sites show very low levels of Potassium which is below 120Kg/ha. Potassium deficiency in soil may affect the resistance capacity of crops from disease and drought tolerance. To increase potash content in soil potassium fertilizer, and banana peels can be applied as natural fertilizer.

*5.8. Iron.*The analysed quantity of Iron in all the collected soil samples satisfies desirable quantity for agricultural soil.

*5.9. Manganese.*The analysed quantity of Manganese in all the collected soil samples satisfies desirable quantity for agricultural soil.

*5.10. Zinc.*The soil samples collected fromKrishnapuram, Alambadi, Marudur, Kulakudi, Kothavacheri, Sattappadi, Thalakulam shows deficiency in Zinc content which is 1.2 ppm. By application of Zinc sulphate or Zinc oxide to soil can correct Zinc deficiency.

*5.11. Copper.*The soil sample collected from Kothavacheri show deficiency of Copper which lies below 1.2ppm. By application of Copper sulphate or Copper oxide are effective ways to increase Copper content in soil.

CONCLUSION

The physico-chemical analysis on the soil samples collected from irrigation areas where mines wastewater from Neyveli open cast lignite mines are analysed. The results obtained from laboratory shows that soil in the study areas lack in Macronutrients Nitrogen, Phosphorous, Potassium compared to normal soil as studies shows (Arvind Kumar Rai, 2011). Thus application of fertilizers to increase the growth and yield of crops suggested for farming in upcoming time. Also levels of Zinc is found to be in less than desirable amount except in Nathamedu.

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