Section A-Research paper
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Evaluation of soil structure and fertility of agricultural fields at Nilgiris – TamilNadu

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Abstract

Agricultural soil mainly consists of minerals, organic matter, water and air. Soil fertility is the ability to improve the plant growth and optimize the yield. The richness of soil fertility is due to the usage of organic and inorganic fertilizers.. For the present study, two agricultural fields were selected. The soil parameters such as physical, chemical and enzymatic activities were analyzed. The color of the soils was reddish brown. The soil textures of both the fields were sandy clay loamy soil. The pH values of both soils were acidic.. The soil structure was determined by the scanning electron microscope. The structures of both the soils were cluster in shape. The macro nutrients such as nitrogen, phosphorus, potassium and micro nutrients such as iron, magnesium, zinc, copper were present within the optimum limit. The enzymes such as Invertase, Urease and Catalase were present in moderate level in both the soils. Presence of high amount of heavy metals in soil leads to the reduction of growth in the plants. The heavy metals such cadmium, chromium, lead, nickel and arsenic were analyzed. All the heavy metals were present within the permissible limit. The results showed that there is a slight variation in both agricultural fields soil. The study concluded that these two agricultural fields were good in their physicochemical and enzymatic parameters and also they were good for the cultivation of crops.

Keywords:- Soil, soil parameters, scanning electron microscope, heavy metals.

Introduction

Soil is one of the principle substrata of life on earth which is found in the uppermost layer of earth crust. Soil is a material which consists of five ingredients that are minerals, soil, organic matter, living organisms, water and gas. Soil fertility is the capacity of soil to supply essential plant nutrients in a particular amount and free from toxic substances. The soil texture and soil structure play a role in influencing pore space and easy movements of air, water and roots through the soil. The Soil enzymes are important for soil health and they act as key factors in decomposing organic matter. The soil parameters such as pH, temperature, moisture and humidity are the important factors to main the soil fertility. The pH of the soil is an important factor which affects the nutrient availability of soil. Heavy metals are metals with a high atomic

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weight and density. They accumulate in the soil through the anthropogenic activities. The soil surface is the important place for storing heavy metals.

The origin of the soils is lateritic which was derived from charnokites known as Nilgiri gneiss. The weathering of minerals occurs due to the climatic condition. The Nilgiri soils are non erodable because of their lateritic origin. Soil structure mainly refers to the spatial arrangement of soil particles. (Hillel, 1998; Brady and Weill, 2008). Soil structure is a dynamic feature which undergoes repeated change. The clusters are formed by the bonding of clay and silt particles. Clusters are mainly formed by the inclusion of some of the colloidal particles such as iron, aluminium and organic colloids (Baver, 1940). The soils which lack colloids constituents do not form aggregated structure.

The physicochemical properties of soils are essential to control the degradation and it increases the farm productivity (Kone et al. 2009). The chemical activities of soil are affected by the physical properties such as texture, structure, and porosity. The supply of nutrients to the plants is affected by some of the chemical properties mainly soil pH. If the soil pH is basic plants cannot take up the nutrients for growth. The soil organic matter content controls the Soil color, pH, and electrical conductivity (Brady and Weil 1996). Soil organic matter is the most important one which determines the soil quality. This organic matter stores the excess amount of carbon.

The heavy metals are a group of elements which consists of transition metals, metalloids, lanthanides and actinides (Singh et al., 2011). The metal arsenic is an abundant element of the earth crust which is chemically classified as those with metallic and non-metallic properties (Nriagu et al., 2007; Kesici, 2016). This metal is present in both organic and inorganic forms, later is present in highly toxic form (Shrivastava et al., 2015).

Soil enzymes are the important key aspects for the biochemical process of organic matter recycling in the soil. The soil enzymatic activities can be used for the improvement of reaction rates for soil processes, microbial activity, and reduces the effect of pollutants etc. (Nare et al., 2014). The fertilization increases the strong influence on soil quality. The organic amendments such as compost, farm yard manure are known to be improve the soil enzymatic activities such as urease, phosphatase and also enhance the soil quality. The amendment of balanced fertilizers improve the soil microbial activity and enzymes (Srinivasarao *et al*.,2013., Mohammadi, 2011)

Materials and methods
STUDY AREA

Figure 1:-Inorganic field- Adigaratti

Figure 2:- Organic field- Thambati

The soil samples were collected from two different agricultural fields of Nilgiris. They are inorganic field- Adigaratti and organic field- Thambati. These two areas are located at the elevation of Adigaratti-2295 (in mts), and Thambatti- 2017 (in mts). Thambatti its Latitude – 11.350896° , longitude – 76.701023° and Adigaratti its Latitude- 11.352591°, Longitude – 76.733324°. The collected soil samples were taken and it was analyzed for different parameters such as physicochemical parameters, enzymatic activity, heavy metals and structure of soils.

Physical parameters:-

Soil texture:- Hydrometer (Bouyoucos, 1927).

Soil color:- Munshell-colour chart.

Soil structure:- SEM, XRD analysis.

Chemical parameters

Soil pH -Potentiometric 1:2 (Jackson, 1973)

EC-electrical conductivity method.

Organic matter - Walkely and Black (Walkely and Black, 1934) .

Macronutrients (N,P,K) - Atomic absorption spectrophotometer.

Micronutrients - DTPA (Lindsay and Norvell, 1978).

Heavy metals - Wet digestion method by ICPMS.

Enzymes - Urease, invertase and catalase - Colorimetric method.

Results and discussion

Soil structure

Scanning electron microscopic images of inorganic field soil and organic field soil.

Figure 3:- SEM for inorganic field soil**.**

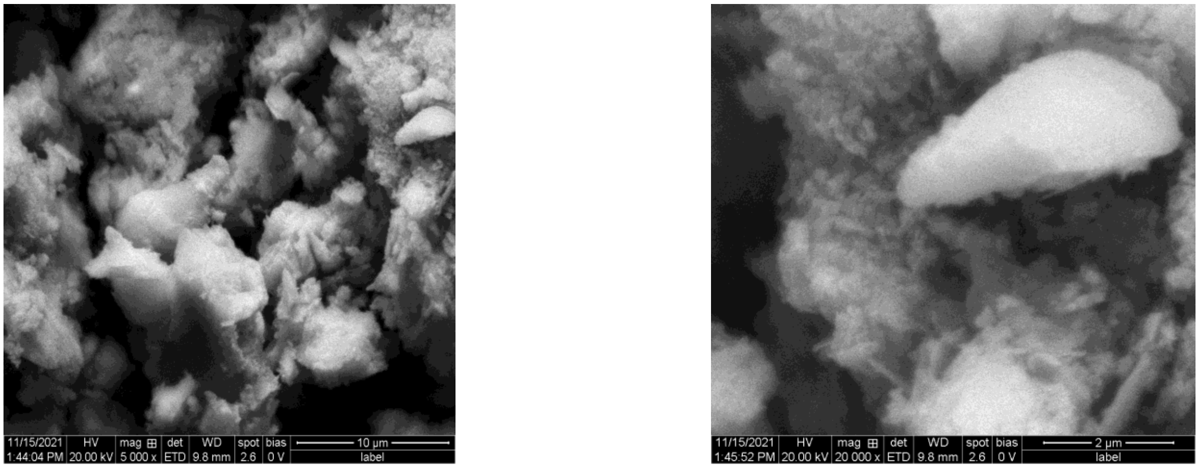
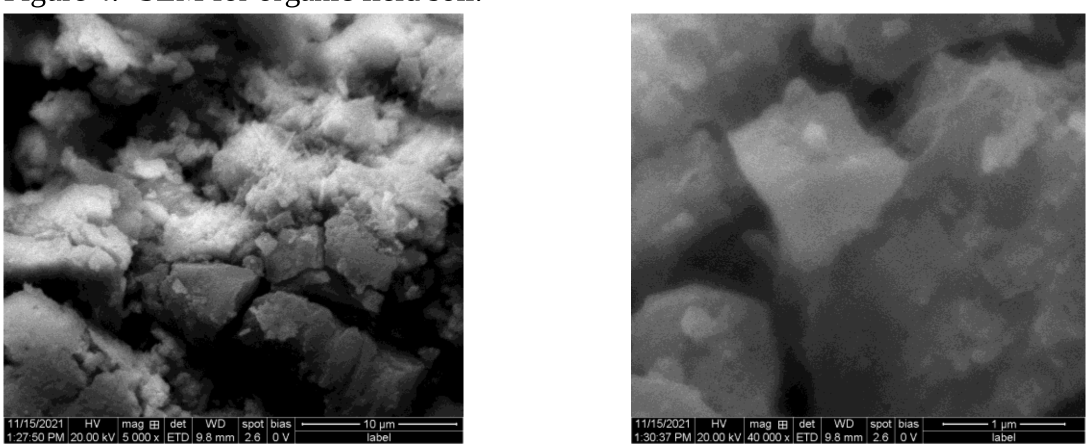
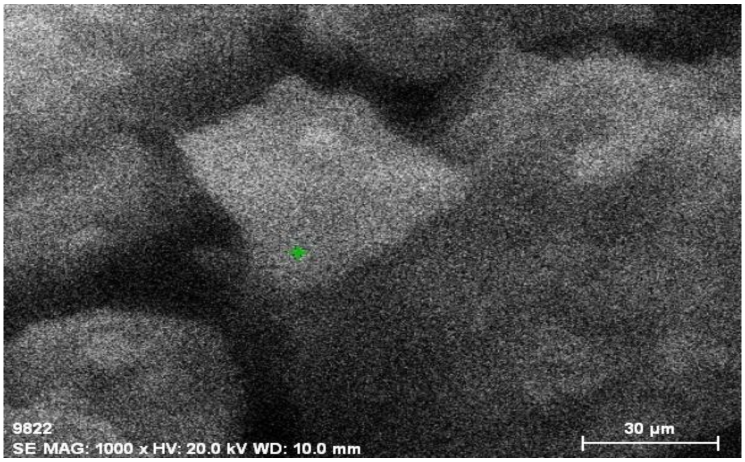


Figure 4:- SEM for organic field soil.



The SEM analysis are magnified many times to observe the surface structure and identify the differences on the structure (Benjamin *et al*., 1978., Hayat, 1978., Goldstein *et al*., 2018). The obtaining the images by SEM, and the point analysis can be done by adding X-ray spectrometer (Goodhew *et al*., 2001., Echlin, 2009., Gira *et al*., 2017., Bergstron, 2015). The qualitative and quantitative analyzes can be done by EDS. Many researchers study the elemental analysis. (Solanki *et al*, 2002., Naswir *et al*., 2013., Ogundalu *et al*., 2014). Liu observed the effect of magnification of soils on SEM images.(Liu et al 2004) The present study of both the fields soil structure shows the cluster in structure. They seem to have many aggregates.

Figure 5: XRD result for inorganic soil



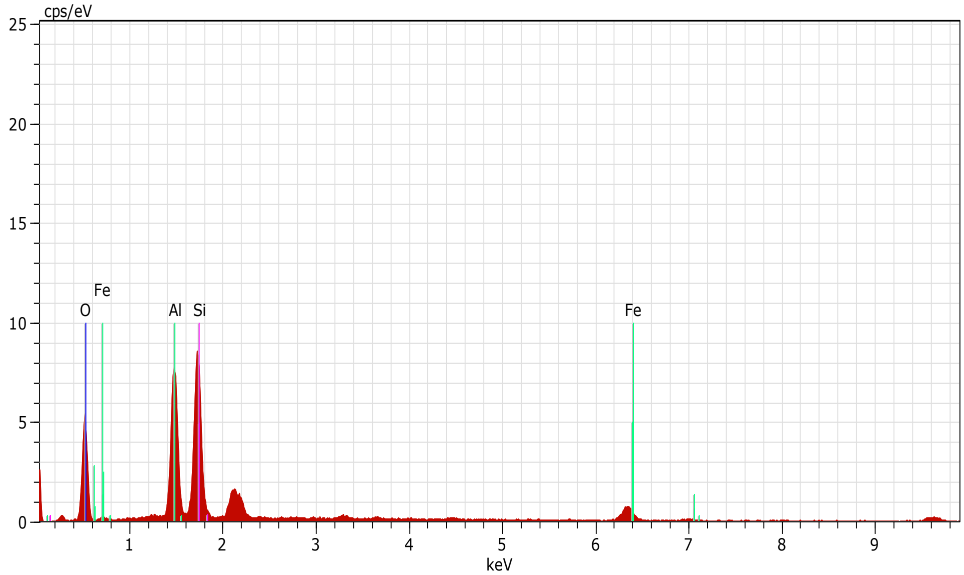
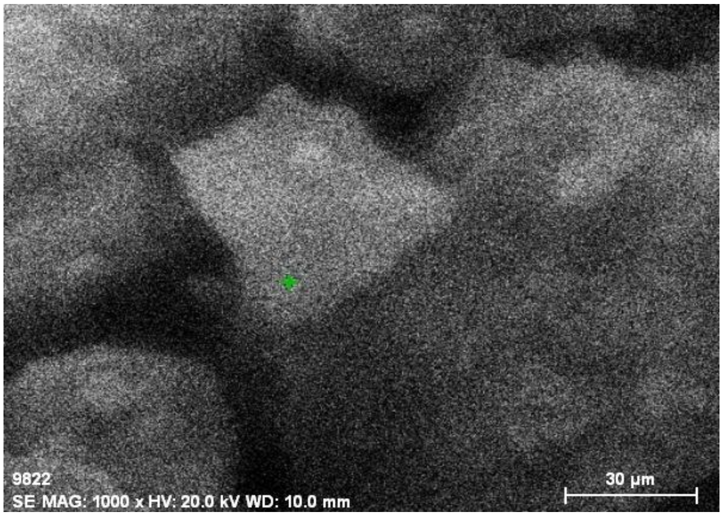
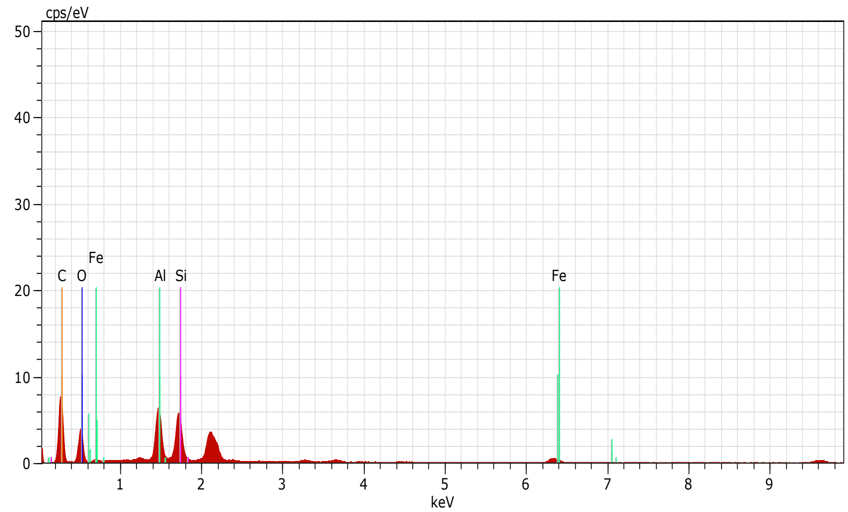


Figure 6: XRD result for organic soil.





Downs reported that it is easy to determine the type of mineral in a soil which contains a mixture of mineral using just two peaks.(Downs et al 1993) The major primary mineral is silicon. According to Karine in the interaction between the x ray and minerals , only the result of certain mineral peaks will appear. (Karine et al, 2005) This inorganic soil consists of minerals such as iron, aluminum, silicon and oxygen. This organic field soil consists of minerals such as iron, aluminum, silicon, carbon and oxygen.

Physical parameters

Table 1: Physical parameters of soils of the study area.

Parameters	**Inorganic soil**	**Organic soil**
Color	Reddish brown	Reddish brown
Texture	Sandy clay loam	Sandy clay loam

Soil color

The soil color is mainly identified by the presence of minerals and the organic matter. The red or yellow soil is identified by the presence of ferric iron oxides (Brady,2006). The color of both the inorganic and organic soil is reddish brown.

Soil texture

Soil texture is an important parameter. It includes the other properties such as water holding capacity, bulk density and hydraulic conductivity which control the nutrients and salts in soil. The agricultural crops mainly prefer the clay loam soil. In the United States, there are twelve classification of soil texture which are described by the United States Department of Agriculture (soil science,2017)The result showed that the texture of both the inorganic and organic soil is sandy clay loam soil.

Chemical parameters

Table 2: Chemical parameters of soils of the study area.

Parameters	**Inorganic soil**	**Organic soil**
pH	6.5	5.8
EC	0.06	0.04
Organic carbon (%)	0.87%	1.25%

pH

The value of pH measures the ratio of H+ ions to OH- base ions in the soil. when the soil solution has more H+, then the soil is considered to be acidic. The OH- ions dominates, then the soil is considered to be alkaline. The equal ratio between the acidic and alkaline is known to be neutral and the value is 7.0. According to (Brady,1995) the pH ranges from 6.5 to 7.5 which is the optimal level for plant nutrient. The result showed that the pH of both the soils is acidic in nature and the value of inorganic soil is 6.5 and organic soil is 5.8.

EC

Mostly EC range is between the value 0–1 dS/m and it indicates good soil health. The value of EC in organic field soil is 0.04 and inorganic soil is 0.06 which indicates these soils are healthy soils.

Organic carbon-

If the range of organic carbon content is < 0.50 %, it is said to be low in carbon and if the soil comes under the range > 0.75 %, the soil is considered very rich in carbon31. Soil organic carbon contains the plant remaining substances, humus and charcoal(Lal, 2007). The present study shows the organic carbon values of both the fields of soil are rich in carbon content.

Table 3: Critical levels of macro nutrients: -

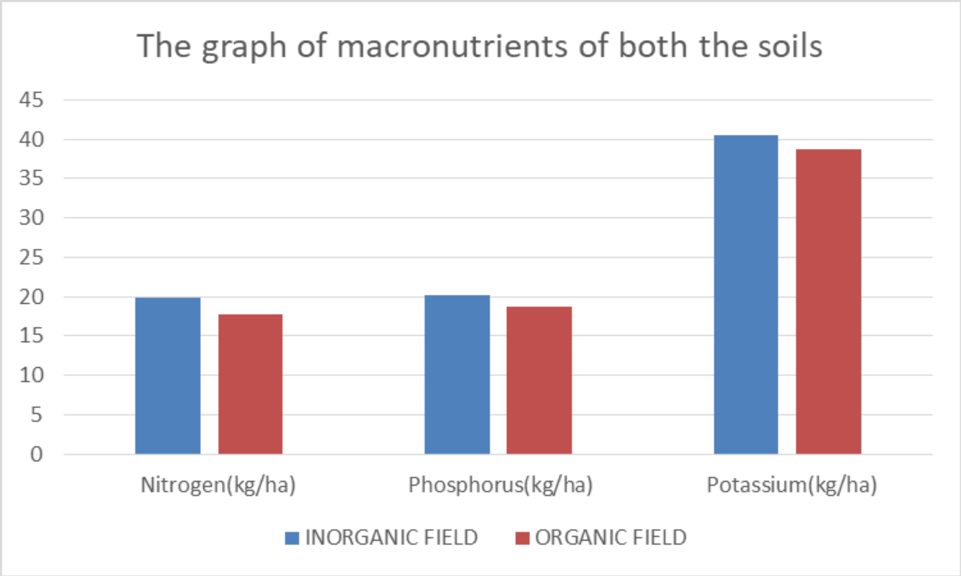
Macronutrients (kg/ha)	Low	Medium	High
Nitrogen	<280	280-560	>560
Phosphorus	< 12.5	12.5-25	> 25
Potassium	< 135	135- 335	>335

(Source: Muhr *et al.*, 1965)

Table 4: Macronutrients levels of the study area.

Macro nutrients	INORGANIC FIELD	ORGANIC FIELD
Nitrogen(kg/ha)	19.82	17.65
Phosphorus(kg/ha)	20.23	18.78
Potassium(kg/ha)	40.46	38.67

Figure 7: Macronutrients levels of the study area



According to (Muhr et al., 1965) in the present study the inorganic field soil the nitrogen was present below the low level, phosphorus was present in medium level. The potassium was present below the low level. In organic field nitrogen was present below the low level and phosphorus was present in medium level. The potassium was present below the low level.

Critical levels of micro nutrients: -

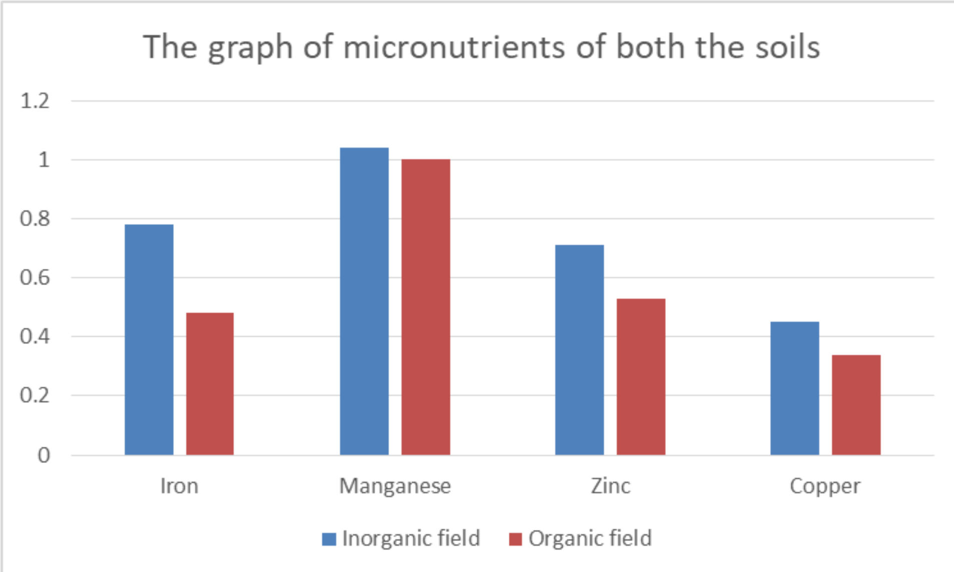
Micronutrients (ppm)	**Critical limit**
Iron	2.5-5.8
Manganese	1.0-2.0
Zinc	0.5-1.0
Copper	0.2-0.5

(Source: Fundamentals of Soil Science, 2009)

Table 5:-Micronutrients levels of the study area.

Micronutrients (ppm)	**Inorganic field**	**Organic field**
Iron	0.78	0.48
Manganese	1.04	1.00
Zinc	0.71	0.53
Copper	0.45	0.34

Figure 8: Micronutrients levels of the study area.



Soil micronutrients

In the present study the result of iron showed that it is present below the critical limit in both the field soils. The values of manganese, zinc, and copper are seen within the critical limit. On comparison the micronutrients the manganese showed the highest value but within the critical limit. The result of micronutrients is seen higher in inorganic soil than organic soil. The result is mainly based on application of fertilizers to the soil.

Soil heavy metal

Heavy metals of soil (ppm)	**Threshold limit (mg/kg)**	**Permissible limit (mg/kg)**
Cadmium	200	250
Chromium	100	200
Lead	60	200
Nickel	50	100
Arsenic	5	50

Table 6 :- Heavy metals contamination of soils of the study area**.**

Metals (ppm)	**Inorganic field**	**Organic field**
Cadmium	1.103	0.963
Chromium	0.714	0.440
Lead	3.761	2.54
Nickel	0.678	0.107
Arsenic	BDL	BDL

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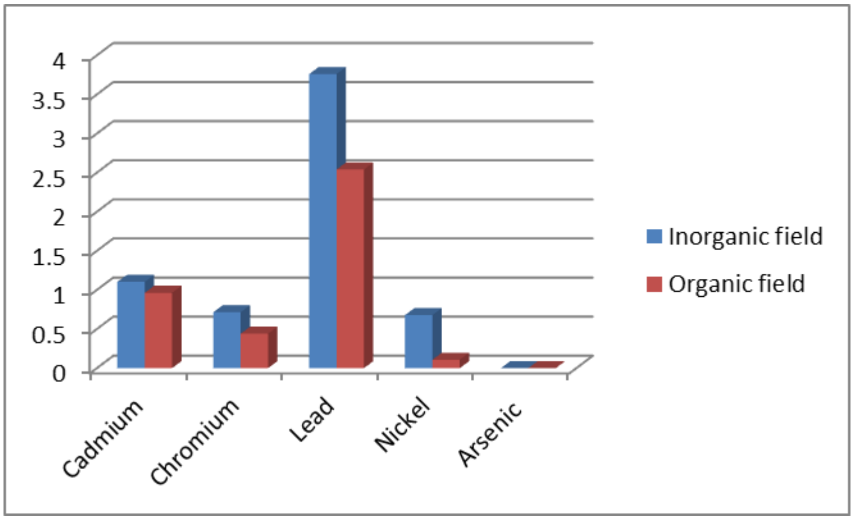
Figure 9: Heavy metal contamination levels of study area.



The above result of heavy metals contamination of soils of the study area showed that the values of the heavy metals such as cadmium, chromium, lead, nickel and arsenic are present below the threshold and permissible limit. The metal arsenic is seen below the detectable limit in both the field soils.

Enzymatic activity of soil

Table 7: - Enzymatic activity of soils of the study area.

ENZYMES	**INORGANIC SOIL**	**ORGANIC SOIL**
Invertase (µg glucose/g/h)	50.77± 3.05	48.32 ± 2.09
Urease (µg NH_{3}-N/g/h)	40.66 ± 2.03	32.54 ± 1.03
Catalase ($KMno_4$/g/h)	1.94 ± 0.08	1.65± 0.05

The enzymes such as invertase, urease and catalase show higher activity in inorganic field soil when compared with organic soil. According to Kanchikerinath and Singh , the urease activity is increased with the application of balanced inorganic fertilizers.(Kanchikerinath and Singh 2001) The enzyme activities such as catalase and invertase treated soil with chemical fertilizer and organic manure were higher than the soils without the treatment of fertilizer. There is no significant difference in the catalase activity after the treatment of fertilization. According to (Xu *et al*. 2004) the different application of fertilization induce the minimal changes in catalase activity. It is said that organic manure which has various enzymes provides the nutrition to the microbial growth and soil enzyme production (Dick *et al*. 1988). Application of organic manure is combined with NPK fertilizer will enhance the soil enzymatic activities.

Conclusion

The present study concluded that the soil tests of both the fields were proven to be good . The structure of both the fields of soils were aggregates. Also the physicochemical parameters were found to be good in condition. The heavy metals contamination of both the soils were below the permissible limit. The enzymatic activity also showed higher activity in inorganic field. The comparison of both the fields showed that the inorganic field- Adigaratti soil has higher value than organic field- Thambatti. It is concluded that soil testing should be carried out from time to time to monitor the soil fertility under continuous cultivation in the agricultural soils.

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