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Elemental content present in food waste and its impacts on physico-chemical parameters of soil

Sonali Sasmal[1], Arun Kumar Pradhan[1], Susanta Kumar Biswal[1] and Atia Arzoo[2*]
[1]Department of Chemistry, School of Applied Sciences, Centurion University of Technology and Management, Odisha, India
[2]Department of Environmental Science, School of Applied Sciences, Centurion University of Technology and Management, Odisha, India
atiaalam21@gmail.com

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Abstract

Food waste is noxious waste which contribute to environmental pollution by its odour which can give the ideal site for flues, damage the surrounding and also create some allergies when reserved for longer time. So reducing the environmental pollution caused by world's population and their necessity, we can employ the food waste as different beneficial ways like bio-fertilizer. We can say that food waste as a perfect bio-fertilizer by knowing the elements present in it through elemental analysis. In the present study it was found that the food waste which cause environmental pollution contains SiO_2, P_2O_5, SO_3, Cl^-, TiO_2, CaO, Fe_2O_3, CuO, ZnO, Br^-, Rb_2O, SrO, Eu_2O_3, K_2O and Re etc. which are major and minor nutrient for plant. So food waste can be used as plant fertilizer due to presence of different micro and macronutrients which neutralize the pH of acidic soil. In the present study, food waste powder was added to the garden soil and both initial and final physico-chemical parameters and elemental contents were analysed. It was observed that the final soil which treated with food waste contained more nutrient than the garden soil. So food waste can be recommended to use as the organic fertilizer which can fulfil the nutrient level of soil and enhance the soil fertility.

Keywords: Food waste, soil, elemental content, physico-chemical parameters.

Introduction

Food waste is that kind of food which lost during different stages of the food supply chain. It is that waste which removed from the food supply chain which is unfit for human consumption or which has spoiled or expired, mainly caused by economic activities and poor stock management. Deposition of organic materials including food waste is becoming more unnatural due to decreased landfill areas and bans on incineration[1]. So, composting has become an environment friendly and cost effective means of converting food wastes from landfills and reducing waste. Food waste compost has not accepted widely due to odour and pest problems associated with conventional waste collection and processing methods[2]. Metals like Al, As, Cd, Co, Cr, Cu, Pb, Mn, Hg, Ni, Se and Zn have been considered as the major environmental pollutants[3] and their toxicity on plants has already been established[4,5]. Some heavy metals like iron, copper and zinc are essential for plants and animals[6]. Other metals like manganese, molybdenum and cobalt are essential micro-nutrients[7], whose uptake in excess to the plant requirements result in toxic effects[8,9].

Materials and methods

Food wastes were collected from lost eaten food where it landfills. It was collected from household food waste. Then these food wastes were sun dried and it was grounded to its powdered form. These food waste powder were used for elemental analysis. These waste powder were also mixed with garden soil and different physico-chemical parameters and elemental content of both garden soil and waste mixed garden soil were analysed. In this study five soil samples from each treatments were collected from a depth of 18cm and mixed to yield a composite sample for analysis. All analysis for all the soil samples were performed at different laboratories of Centurion University of Technology and Management, Odisha, based on standard procedures[10]. This present study has emphasized on the study of presence of different elements on the food waste and its impacts on soil quality.

Soil samples were collected from a garden of Centurion University of Technology and Management, BBSR, Odisha at depths of 18cm using stainless steel soil auger. The samples were transferred into polyethylene bags and labelled for easy identification. Then the collected samples were taken to the laboratory and treatment was done for the preservation of soil and further analysis has been done as per standard procedure. The collected samples were air dried in sun light for about twenty four hour. Then the samples were dried in an oven at $105^{\circ}C$ till complete dehydration. Then the sample was ground in a wooden mortar then passed through 0.5mm nylon mesh sieve. These soil samples were again packed with the complete labelling and preserved for further analysis.

Food wastes were collected from dumping site near CUTM ladies hostel. The physico-chemical parameters like pH, E.C., soil moisture percent (%), water holding capacity of soil and elemental content of both soil and food waste were analyzed using standard methods[11].

Results and discussion

The physico-chemical parameter like pH, Electrical Conductivity (E.C.), soil moisture conten (%), water holding capacity (W.H.C.), and different elements/compound contents of a garden soil and garden soil treated with food waste were analysed and both the results were compared.

Physical parameters: pH: pH of soil sample indicates the amount of acid or base present in it. If the pH is 7. It is said to be neutral, when it is more than 7 then the soil sample is considered as basic and when less than 7 then the soil sample is acidic. pH levels can be critical to plant's ability to absorb nutrients. The pH values of the soil sample collected from our college garden area was found within 7.4 to 7.6 (Table-1). So the soil sample was considered to be basic. After addition of Food waste it was found to be 6.8 to 7.1 which indicate that the food waste neutralizes the alkaline soil.

Electrical Conductivity: The measure of electrical conductivity is directly related to the concentration of ionised substances in soil solution and may also be related problems of excessive hardness or other mineral contaminants. The conductivity values in the soil samples of the area under study were found to range 0.86 to 0.89Mho/cm (Table-1). After addition of food waste it was found to be 0.91 to 0.98Mho/cm. It was found that after addition food waste on it, it's value was increased.

Table-1: Different physical parameter of Garden soil (Initial soil) and garden soil treated with food waste.

Parameter	Unit	Garden soil	Garden soil + food waste
pH	——	7.5 ± 0.057	6.96 ± 0.12
Electrical Conductivity	mho/cm	0.89 ± 0.08	0.91 ± 0.09
Water Holding Capacity	mg/kg	157.54 ± 0.583	152.54 ± 0.41
Moisture Content	%	11 ± 0.57	8.66 ± 0.88

Values of five replicates ± SEM.

Soil Moisture Content: Moisture content in soil is the vital factor for plant growth. Moisture content in soil is the amount of water contained in soil. This soil had moisture content within the range of 11 to 12%. After adding the food waste on soil, it's value was found to be 9 to 10% (Table-1). It was found that after addition of food waste the percent of moisture content decreased.

Water Holding Capacity (W.H.C.): Soil water holding capacity is the amount of water that soil can hold. In this study the soil had range between 157.53 to 158.55ml water holding capacity (Table-1). After addition of food waste it was found to be the range of 153.28 to 153.85ml. It showed that after addition of food waste the range of water holding capacity was decreased.

Elements/Compounds present: In this study, elemental analysis of soil had been done in the basis of XRF (X-ray fluorescence). The soil was found to be contained many elements/compounds i.e. Al_2O_3, SiO_2, P_2O_5, SO_3, Cl, K_2O, CaO, MnO (Table-2).

Aluminium Trioxide (Al_2O_3): Aluminium Oxide is an oxide of aluminium, occurring in nature as various mineral ores such as bauxite. The garden soil was found with 15.71% in Aluminium trioxide. After addition of food waste in soil, it was decreased to 15.692%.

Silicon Dioxide (SiO_2): Silicon is an element which can be abundantly found in earth crust. Silica is the common term for the compound Silicon dioxide. It is formed when silicon comes in to contact with Oxygen. The soil under analysis was found to be 66.18% of silicon dioxide. After addition of food waste in soil, it was decreased to 62.72%.

Phosphorus Pentoxide (P_2O_5): It is water soluble element. So it is used as fertilizer in crop fields. It can be applied at any time but has good use as fertilizer not a plant nutrient, and clayey soils, should be avoided. Under analysis, the soil contained about 1.034 % of phosphorus pentoxide. After addition of food waste in soil, it was increased to 4.436%.

Titanium Dioxide (TiO_2): Titanium dioxide is considered an emerging contaminants are polluted increasingly released into the environment, including agricultural fields, their potential impacts on soil and its function remain to investigated. The soil was contained 1.44% of titanium dioxide. After addition of food waste in soil, it was deceased to 1.281%.

Vanadium Pentoxide (V_2O_5): Vanadium is naturally released to the soil which occurs primarily as a result of weathering of rocks and soil erosion which involves the conversion of the less-soluble penta-valent form. It is mainly found in the form of iron and aluminium hydroxides which determine vanadium mobility in soils. The soil was contained 336.33ppm of vanadium pentoxide. After addition of food waste in soil, the value would be 283.7ppm. It indicates that the value was decreased.

Zicronium Dioxide (ZrO_2): The present study focused on the ecotoxicological behaviour of bulk and nano zicronia particles on plant growth promoting rhizobacteria, soil and its nutrient contents. The soil under analysis had 0.132% zicronium dioxide. After addition of food waste in soil, it was decreased to 0.26%.

Calcium Oxide (CaO): Calcium is an important mineral i.e major element used in plant nutrition. Soils, which contain less amount of calcium shows limited growth of plant. The calcium in the soil was added to nutralize the soil as fertilizer originated in the rocks and minerals from which the soil was formed. This soil was contained 4.175% of calcium oxide. After addition of food waste in soil, it was found to be 7.023%. It shows that calcium oxide was increased.

Table-2: Different elements/compounds present in garden soil, food waste and garden soil mixed with food waste.

Elements/ Compounds	Unit	Garden Soil	Food waste	Garden soil + Food waste
Al_2O_3	%	15.712 ± 0.63	0	15.692 ± 0.08
SiO_2	%	66.182 ± 0.602	3.098 ± 0.037	62.721 ± 0.701
P_2O_5	%	1.034 ± 0.002	10.376 ± 0.058	4.345 ± 0.08
SO_3	%	0.662 ± 0.08	9.570 ± 0.354	2.389 ± 0.092
Cl	%	0.551 ± 0.005	26.246 ± 0.053	1.516 ± 0.055
K_2O	%	0.217 ± 0.005	33.198 ± 0.04	5.306 ± 0.90
CaO	%	4.175 ± 0.088	14.703 ± 0.096	7.023 ± 0.093
TiO_2	%	1.444 ± 0.177	0.266 ± 0.008	1.281 ± 0.023
MnO	%	0.145 ± 0.002	0	0.138 ± 0.004
ZrO_2	%	0.132 ± 0.001	0	0.126 ± 0.002
Fe_2O_3	%	6.324 ± 0.08	1.267 ± 0.07	6.328 ± 0.09
V_2O_5	Ppm	336.33 ± 0.24	0	283.7 ± 0.15
Cr_2O_3	Ppm	193.13 ± 0.57	0	146.0 ± 0.38
NiO	Ppm	74.266 ± 0.17	0	72.42 ± 0.12
ZnO	Ppm	147.43 ± 0.26	0.144 ± 0.011	144.12 ± 0.23
Ga_2O_3	Ppm	32.466 ± 0.26	0	27.7 ± 0.08
Rb_2O	Ppm	136.36 ± 0.18	408.8 ± 0.25	147.8 ±0.29
As_2O_3	Ppm	13.36 ± 0.04	0	11.21 ± 0.12
SrO	Ppm	132.166 ± 0.21	163.86 ± 0.18	139.8 ± 0.29
Y_2O_3	Ppm	37.2 ± 0.35	0	36.9 ± 0.29
Nb_2O_5	Ppm	32.726 ± 0.14	0	32.1 ± 0.13
SnO_2	Ppm	95.23 ± 0.12	0	91.23 ± 0.13
Eu_2O_3	Ppm	673.16 ± 0.14	0.540 ± 0.028	604.36 ± 0.48
Yb_2O_3	Ppm	48.433 ± 0.29	0	47.6 ± 0.12
ThO_2	Ppm	43.86 ± 0.185	0	54.3 ± 0.58
Re	Ppm	0	49.633 ± 0.088	4.4 ± 0.008
CuO	Ppm	101.9 ± 0.24	0	98.32 ± 0.06

Values of five replicates ± SEM

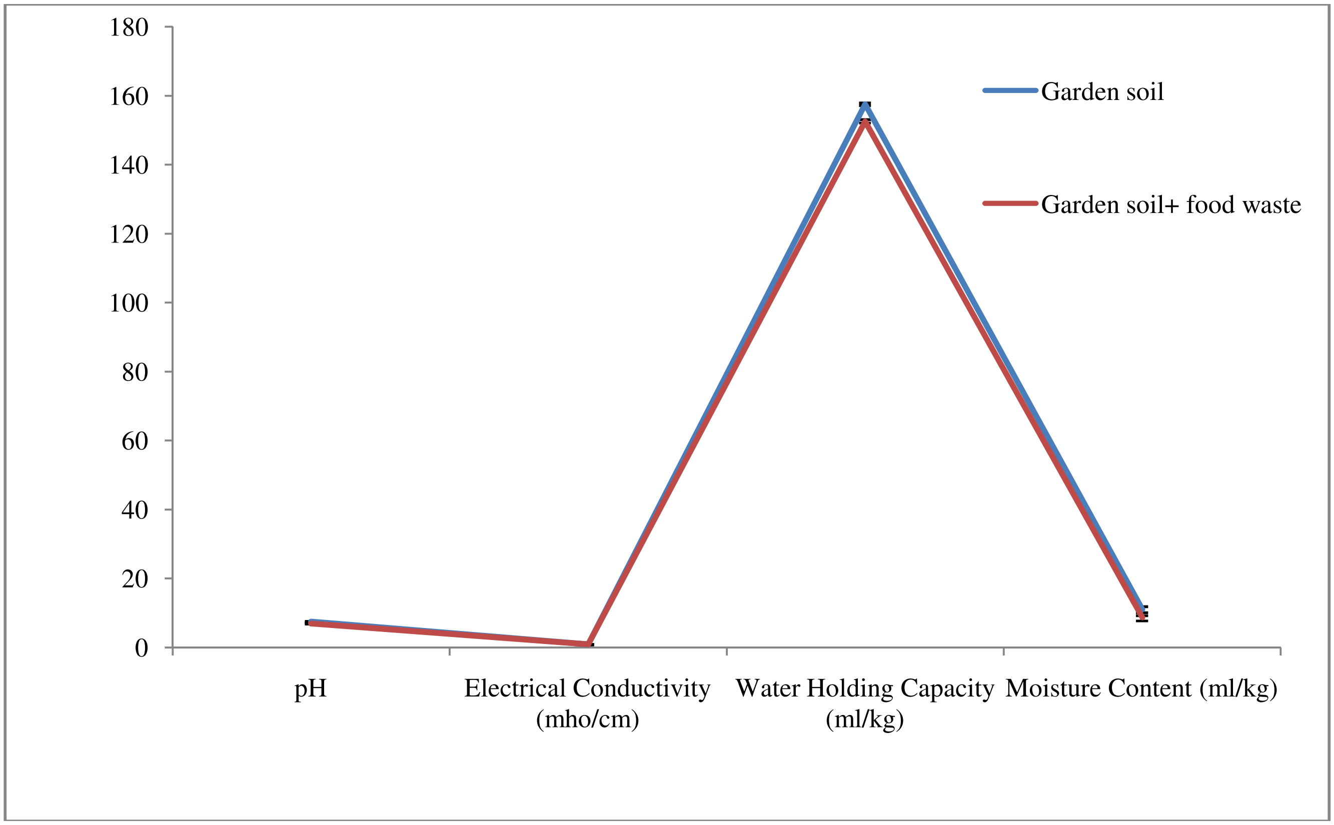

Figure-1: Different physical parameter of Garden soil (Initial soil) and garden soil treated with food waste.

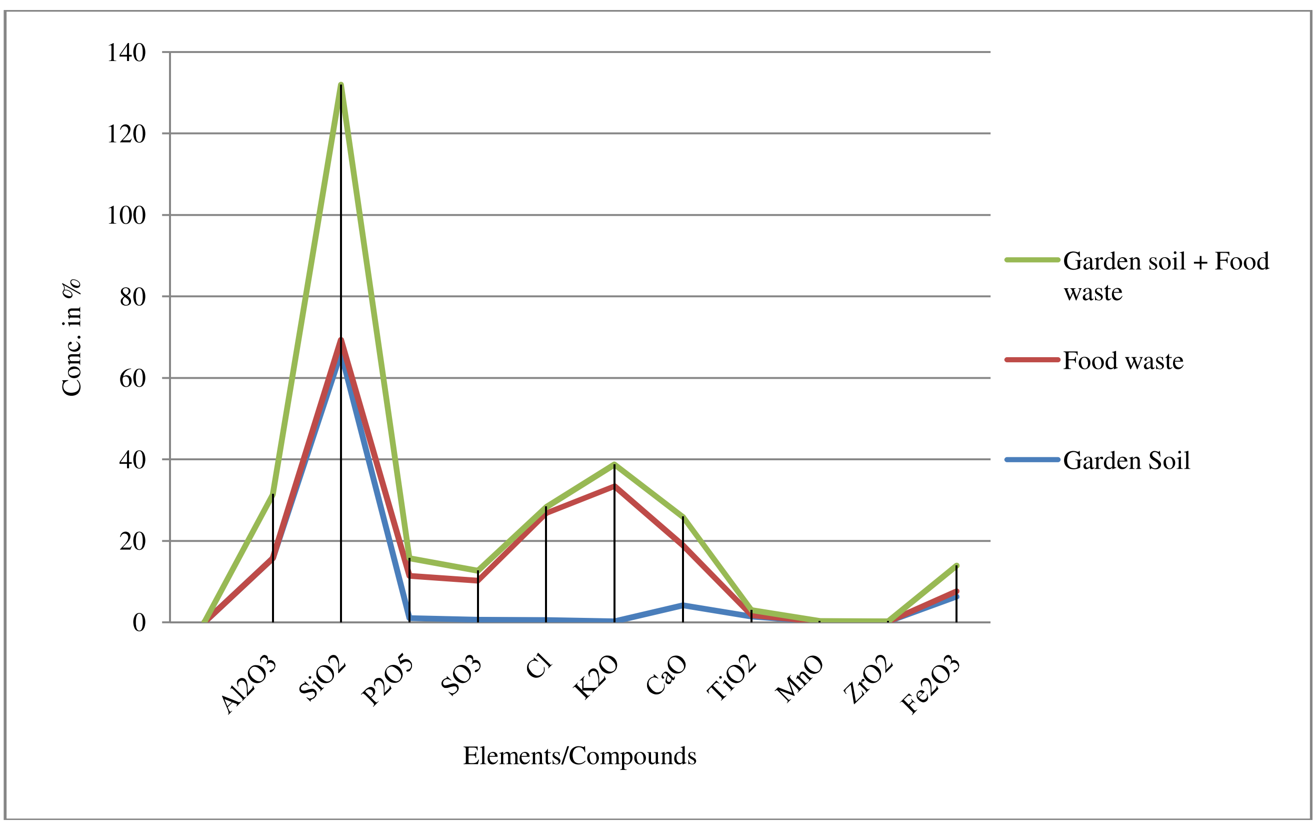

Figure-2: Different major elements/compounds present in garden soil, food waste and garden soil mixed with food waste.

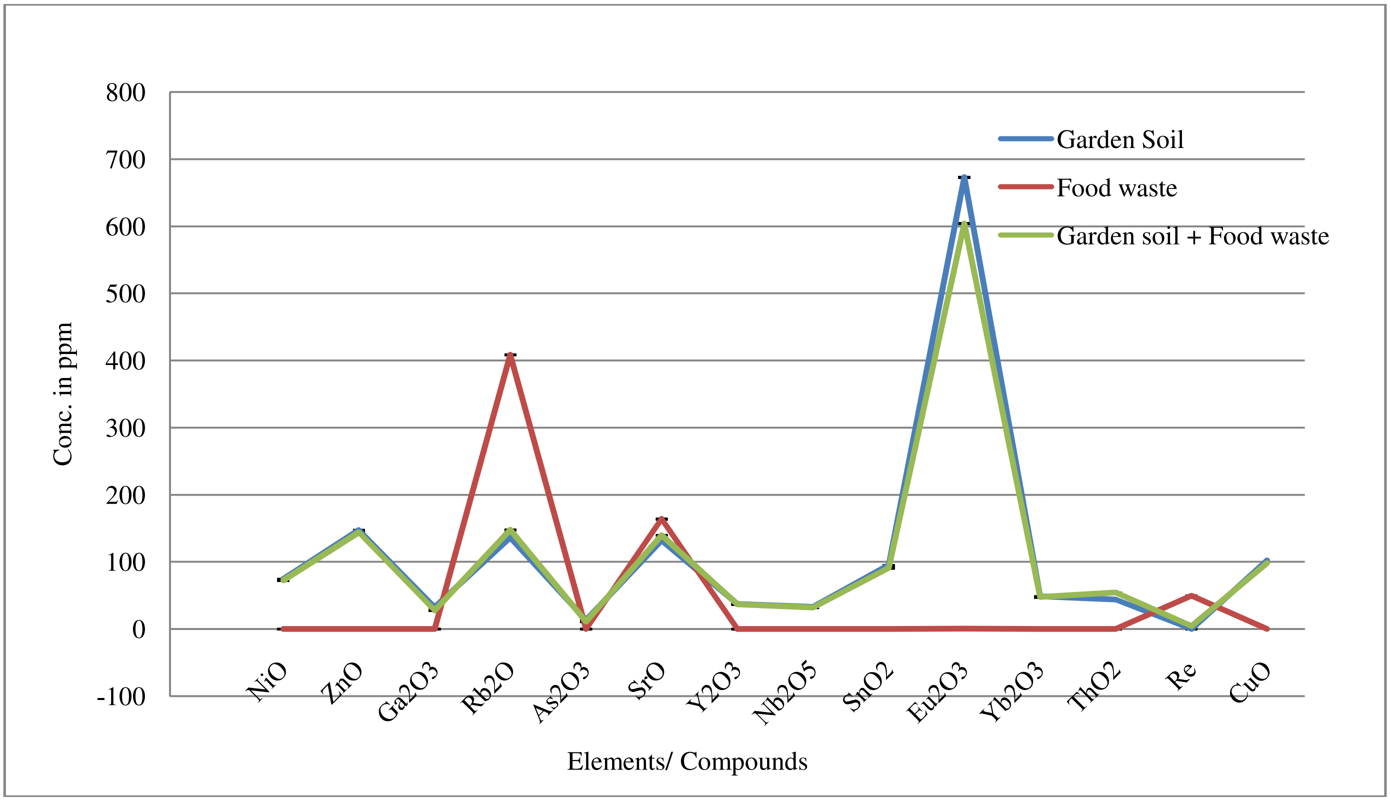

Figure-3: Different minor elements/compounds present in garden soil, food waste and garden soil mixed with food waste.

Potassium Oxide (K_2O): Potassium is one of the among "big three" soil nutrients- nitrogen, phosphorus, and potassium. It plays an important role in nutrition and metabolism of plants. It has an important role in breakdown of carbohydrate which releases energy for plant growth. Potassium also increases drought resistance capacity in plants and aid in reducing plant water loss. The soil under analysis had 0.217% of potassium oxide in it. After addition of food waste in soil, it was increased to 5.306%.

Copper Oxide (CuO): Copper (Cu) deficiency affects in the growth and metabolism in plants, specifically photosynthesis and respiration. It can lead to reduce crop productivity, thus developing many unfilled grains. The soil under analysis had 101.9ppm copper oxide on it. After addition of food waste in soil, it was increased to 98.32ppm.

Zinc Oxide (ZnO): Zinc deficiency is found to be common in many different types of soil and others have low plant-available zinc due to strong zinc sorption. Soils low in organic matter and compacted soils that restrict root proliferation also have a high risk of zinc deficiency. The soil under analysis had 147.433ppm of zinc oxide. After addition of food waste on soil, it was decreased to 144.12ppm.

Rubidium Oxide (Rb_2O): Rubidium oxide is hydrophilic in nature and it would not be expected to occur naturally. In the present study the garden soil was contented 136.36ppm of rubidium oxide. After addition of food waste in soil, it was increased to 147.8ppm.

Sulphur Trioxide (SO_3): Sulphur trioxide, is a colour less to white crystalline solid which creates fume in air. It reacts violently with water to from sulfuric acid with release of heat. The soil was contented 0.662% of sulphur trioxide. After addition of food waste in soil, it was increased to 2.389%.

Chloride (Cl): Chlorine is an element which is taken up by the plant in form of chloride ion from soil solution. Chloride plays important roles in plants growth and development. High concentrations of chloride can reduce the crop yield. The soil was contented 0.551 percent of chloride. After addition of food waste in soil, it was increased to 1.516%.

Chromium Oxide (Cr_2O_3): Chromium is a major pollutant in which the oxidation state of is found in different states which is an important indicator of toxicity in soil and potential mobility. In the present study the soil was contented 193.13ppm of chromium oxide. After addition of food waste in soil, it was decreased to 146.0ppm.

Nickel Oxide (NiO): In the present study the soil was contented 74.26ppm of nickel oxide. After addition of food waste in soil, it was decreased to 72.42ppm.

Strontium Oxide (SrO): Strontium oxide is formed, when strontium reacts with oxygen. The soil was contented

132.16ppm of strontium oxide. After addition of food waste in soil, it was increased to 139.8ppm.

Diarsenic Trioxide (As_2O_3): In the present study the soil was contented 13.23ppm of diarsenic trioxide. After addition of food waste in soil, it was decreased to 11.21ppm.

Manganese Oxide (MnO): Manganese deficiency in plant causes plant disorder. In this disorder plants shows symptoms include yellowing of leaves with smallest leaf veins remaining green to produce a chequered effect. The soil was contented 0.145 percent of manganese oxide. After addition of food waste in soil, It was decreased to 0.138%.

Yttrium Oxide (Y_2O_3): Yttrium is used in making red phosphors which is used for colour television picture tubes. The soil was contented 37.2ppm of yttrium oxide. After addition of food waste in soil, it was decreased to 36.9ppm.

Gallium Oxide (Ga_2O_3): The garden soil under analysis had 32.466ppm of gallium oxide. After addition of food waste in soil, it was decreased to 27.7ppm.

Ferric Oxide (Fe_2O_3): Ferric oxide is a compound of iron which is abundantly present in soil that gives dirt a distinctive red colour, and plants can absorb iron from this compound. The garden soil under analysis had 6.324% of ferric oxide. After addition of food waste in soil, it was neutral as 6.328%.

Niobium Pentoxide (Nb_2O_5): Niobium oxide is a highly insoluble and thermally stable niobium source suitable for glass and optic. The soil was contented 32.72ppm of niobium pentoxide. After addition of food waste in soil, it was decreased to 32.1ppm.

Tin Oxide (SnO_2): Tin oxide can be used as a polishing powder, sometimes it can be used in mixture with lead oxide, for polishing glass and silver. The garden soil was contained 95.23ppm of tin oxide. After addition of food waste in soil, it was decreased to 91.23ppm.

Thorium dioxide (ThO_2): The garden soil was contained 43.86 ppm of thorium dioxide. After addition of food waste in soil, it was increased to 54.3ppm.

Rhenium (Re): It is the most expensive and rare metals can be derived from the soil in an eco friendly way using Lucerne. The garden soil was not contained rhenium. After addition of food waste in soil, it was decreased to 4.4ppm.

In this present study physico-chemical parameter like pH, Electrical Conductivity (E.C.), soil moisture content (%), water holding capacity (W.H.C.), and different elements/compound contents present in soil were analyzed. It was found that after addition of Food waste the pH was found in the range of 6.8 to 7.1 which indicates that the food waste neutralizes the alkaline soil. Electrical conductivity was found in the range of 0.91 to 0.98Mho/cm. It was found that after addition food waste on it, it's value was increased. Water holding capacity was found in the range of 153.28 to 153.85mg. It showed that after addition of food waste the range of water holding capacity was decreased. it was found that the food waste which cause environmental pollution contains SiO_2, P_2O_5, SO_3, Cl^-, TiO_2, CaO, Fe_2O_3, CuO, ZnO, Br^-, Rb_2O, SrO, Eu_2O_3, K_2O and Re etc. which is major and minor element for plant. Similar results were also found from different literature such as From some experiment it was found that, the slow discharge of nitrogen supplied by food waste composts are perfectly suited for urban landscapes where moderate, consistent rate of plant growth is highly desirable[12]. Some metals like iron, copper and zinc are essential for plants and animals. The availability of some metals such as copper, zinc, iron, manganese, molybdenum, nickel and copper varies and such metals are essential micronutrients[13]. Compost prepared from organic wastes[14]; when applied on land; increase soil organic matter[15] and provide plant nutrients in a slowly available form[16].

Conclusion

Food waste can be used as plant fertilizer due to presence of different micro and macronutrients which neutralize the pH of acidic soil. In the present study, food waste powder was added to the garden soil and both initial and final physico-chemical parameters and elemental contents were analysed. It was observed that the final soil which treated with food waste contained more nutrient than the garden soil. Food waste can be recommended for used in agricultural field as organic fertiliser.

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