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Assessment of Differential Sheer Stress Indices in Agricultural Soil Receiving Cafeteria Effluent

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ABSTRACT

This study looked at assessing the impact of waste water from a cafeteria in University of Nigeria, Nsukka on soil physicochemical properties and quality marker enzyme activity. Physicochemical analysis of the soil before and after irrigation with the domestic waste water from the cafeteria showed the presence of the following: pH 7.4 and 6.65, conductivity 488 and 792 respectively. Dissolved mineral contents were found in the following order: Cl>Ca>Fe>SO_4>Mg>Cu>K>Pb>PO_3 while heavy metals of Hg, As and Cd were found at below detectable limit range (BDL) in both the irrigated and non-irrigated soil. Total organic matter (TOM) and total organic carbon (TOC) contents were found at 91.66, 22.05 and 76.85, 179.93 in the various treatments, respectively. BOD_5 of the waste water was found at 5.2mg/ml with initial dissolved oxygen concentrations at 6.2 mg/ml. Dissolved mineral concentrations such as Cl, Ca, Mg, PO_3, Cu, Fe and SO_4 were found richly in abundance. Heavy metals such as Pb was found in trace quantity were as Cd, As and Hg were found in non-detectable range. TDS, TSS and TS were recorded at 23036, 396.5 and 23433. Analysis of soil enzymes showed the activity of the lipase, urease, peroxidase and catalase with corresponding OD reading of 0.403, 0.611, 0.652 and 0.817 respectively. There was an increase of lipase, urease and peroxidase after the irrigation with the waste with OD of 0.610, 0.677 and 0.712 respectively while catalase activity was reduced.

Keywords: Enzymes, physicochemical, heavy metals, waste water, soil.

INTRODUCTION

The use of municipal waste water and effluent of domestic constituents on agricultural soil have provided a salvage pathway for waste disposal through utilization of the recyclable constituents in the waste water for optimized agricultural produce (Khalid *et al*., 2017).

Wastewater production sources include different human activities, such as: Industrial, commercial, and domestic activities (Alobaidy *et al.,* 2010). Municipal wastewater is also sometimes distinguished into urban, rural, and agricultural areas and sources. With the rapid expansion of human population, cities, industries, and the domestic water supply, the quantity of wastewater production is increasing at the same proportion (Khalid *et al*., 2017). The average volume of wastewater generated daily by human activities depends on the availability of the water quantity used in the house, the cultural level and type, the cost of the water, and the economic conditions (Alobaidy *et al*., 2010).

Agriculture is the most common sector in which untreated wastewater is reused. According to an estimate in 2004, approximately 20 million ha is irrigated with wastewater in fifty countries worldwide (Chen *et al*., 2013). The use of wastewater for crop irrigation has further increased in recent years. The municipal wastewater demand corresponds to 11% of the water withdrawal globally (Thebo *et al*., 2017). About 3% of the municipal wastewater demand is consumed and the remaining 8% is being discharged as wastewater; that is, 330 km^3 of wastewater per year, which is potentially irrigating almost 40 million ha (approximately 8000 m^3 per ha) or 15% of all irrigated lands (Chen *et al*., 2013).

Wastewater usage for crop irrigation has certain advantages such as providing the essential nutrients and organic matter to the soil, saving water and nutrients for biogeochemical cycling, and reducing water contamination as a result of surges into domestic supply (Huibers *et al*., 2005). It has been reported that quite sufficient quantities of macronutrients (N, P, and K) are supplied to soil and plants via wastewater application (Huibers *et al*., 2005). Therefore, it is a great temptation for poor farmers to irrigate crops with wastewater as it can reduce the crop production cost (WHO, 2006).

The fundamental problem facing our country Nigeria is inadequate machinery in waste management. This is to an extent due to the bridge of policies, inadequate infrastructure and economic challenges. This has hampered the nation's economic developments in agriculture, industrial and otherwise (Emeka, 2008). Agriculture still stands out as a major fulcrum in our country's major developmental stride for the achievements of her dream 2020. Over the years, records from ecological impact assessments have shown how various wastes from different sources have impacted on the various ecological niches/properties of our biosphere. These records have kept mouth shattering of the sustainability our environment (soil) which is the center for various earthly activities (Ajanaku, 2007). Sustainability of the agricultural sector in our developing country Nigeria cannot be over emphasized; assessment of quality markers of soil for efficient agricultural practices gives a view of the level of recalcitrant present in the soil. Agricultural practices and its bountifulness can only improve when the integrity of the surrounding soil is not compromised. The present study provides information on the impact of agricultural soil contaminated with cafeteria waste water on soil physicochemical properties and soil quality marker enzymes.

MATERIALS AND METHODS

Materials

All the reagents, equipment used in the present study were of analytical grade and products of Bristol, May and Baker, Sigma Aldrich. The equipment is calibrated at each use.

Collection of the Experimental Samples

Soil samples

Arable soil was collected from the back of soil science Department University of Nigeria, Nsukka Enugu state (Long.14^0N, SE 4) as described by Ezeonu *et al*. (2013). The soil was collected in sterile sample containers and was taken to the lab for further experiments

Collection of Water Sample

Domestic waste water was collected from the kitchen reservoir of a Cafeteria located within the premise of University of Nigeria, Nsukka Enugu state; the water was collected using sterile sample bottle as described in the journal of Agency for Toxic Substance and Disease Registry (2009) and was taken to the department of biochemistry laboratory for further analysis.

Determination of physicochemical properties of the soil and waste water

Soil and waste water physicochemical properties were determined as described in the journal of ATSDR, 2009. Physicochemical properties: pH, conductivity, dissolved minerals (Cl, Mg, Ca, K, PO_3, TS, TDS, TSS, DO, BOD, heavy metals (As, Cd, Cr, Hg, Pb, Cu) were assessed.

Contamination of the Soil with the Petroleum Effluents

Soil sample gotten from Soil Science Garden of University of Nigeria, Nsukka was polluted with the effluents from the cafeteria surge tank at concentrations of 0 (control), 10, 50 and 100 % (v/50kg) as described by Vallero (2010). The polluted soils and the control experiment were acclimatized for 12 hours after the pollution prior to the assessment studies. Physicochemical properties of the polluted soil samples were also analyzed as described in section above.

Soil Enzyme Assessment

Soil quality marker enzymes were determined using standard assay protocols, enzyme such as: Lipase, catalase, urease and peroxidase were assayed as described by Okwaye *et al*. (2010), Latha (2013), Douglas and Bremner (1971) respectively.

Statistical Analysis

One way analysis of variance (ANOVA) and statistical micro word excel was used in the analysis of the data. T-student test was used to compare the data significances.

RESULTS

Table (1) shows the physicochemical properties of the waste water from municipal ditch characterized with cafeteria effluent. The results showed very much in contrast the properties of the waste water from the control experiment.

Table (2) shows the physicochemical properties of the waste water from municipal ditch characterized with cafeteria effluent. The results showed very much in contrast the properties of the waste water from the control experiment. Comparatively soil samples impacted with the cafeteria effluent showed significant impact in the physicochemical properties of the soil compared to the control experiment.

Table 1: Physicochemical Properties of the Waste Water.

Physiochemical Parameters	Control Water Sample	Waste Water Sample
pH	7.20	5.30
Water Conductivity ($\Omega^{-1}cm^{-1}$)	782	913
Chloride ion (Mg/L)	7123	1203.42
Dissolved oxygen (Mg/L)	7.02	5.76
Magnesium (Mg/L)	16.24	24.21
Potassium (Mg/L)	1.02	8.18
Calcium (Mg/L)	32.33	39.76
B0D5	0.93	4.02
Iron (Mg/L)	1.25	22.29
Cadmium (Mg/L)	BDL	BDL
Mercury (Mg/L)	BDL	BDL
Arsenic (Mg/L)	BDL	BDL
Lead (Mg/L)	BDL	10.32
Copper (Mg/L)	1.14	17.22
Total Organic Carbon (TOC) (mg/L)	38.40	184.41
Total Organic Matter (mg/L)	46.74	226.82

N=2

Table 2: Physicochemical Properties of the Soil

Physiochemical Parameters	Control Soil Sample	Treated Soil Sample
pH	7.40	6.65
Soil Conductivity ($\Omega^{-1}cm^{-1}$)	488	792
Chloride ion (Mg/kg)	698	1162.91
Phosphorus (Mg/kg)	2.92	5.81
Magnesium (Mg/kg)	20.17	14.62
Potassium (Mg/kg)	9.62	7.25
Calcium (Mg/kg)	28.43	26.21
SO_4 (Mg/kg)	15.39	17.44
Iron (Mg/kg)	16.55	24.15
Cadmium (Mg/kg)	BDL	BDL
Mercury (Mg/kg)	BDL	BDL
Arsenic (Mg/kg)	BDL	BDL
Lead (Mg/kg)	5.23	6.30
Copper (Mg/kg)	4.28	14.12
Total Organic Carbon (TOC) (Mg/kg)	76.85	179.93
Total Organic Matter	91.66	221.05
Soil Temperature	34.5^0C	36.0^0C

N=2

Fig. (1) shows the activity of the identified soil quality marker enzymes from the agricultural soil contaminated with the municipal waste water and the control experiment.

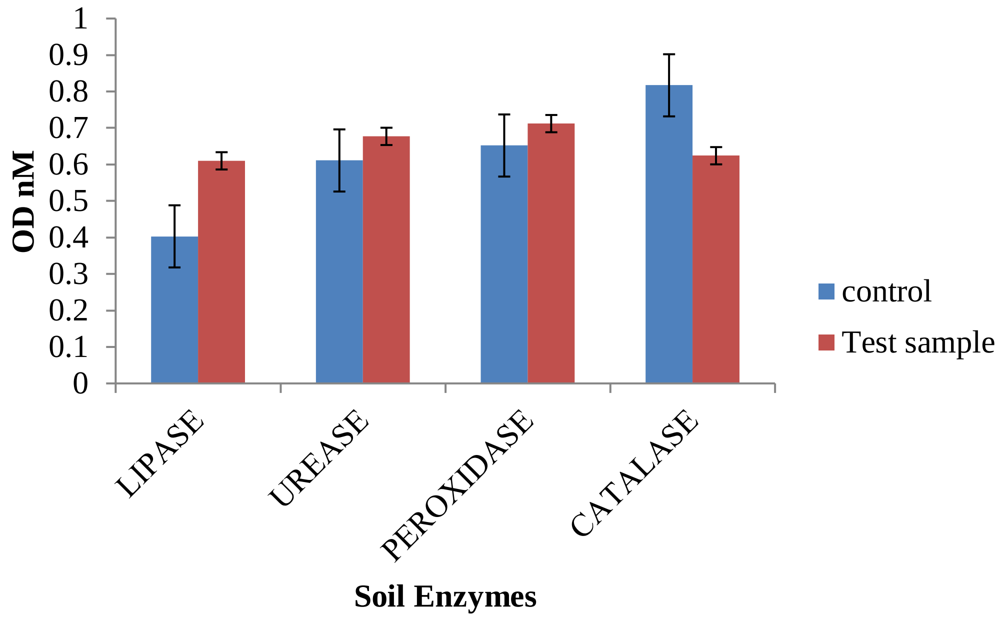

Fig. 1: The activity of the identified soil quality marker enzymes

DISCUSSION

The use of municipal waste water and effluent of domestic constituents on agricultural soil have provided a salvage pathway for waste disposal through utilization of the recyclable constituents in the waste water for optimized agricultural produce. Besides these benefits, a number of drawbacks are associated with the use of wastewater for crop irrigation (WHO, 2006). Wastewater contains potentially toxic elements (PTEs) such as zinc, chromium, copper, cadmium, nickel, lead, mercury, and parasitic worms, which can induce severe risks to the human health and the environment.

This study looked at assessing the impact of waste water from a cafeteria in University of Nigeria, Nsukka on soil physicochemical properties and quality marker enzyme activity. Physicochemical analysis of the soil before and after irrigation with the domestic waste water from the cafeteria showed the presence of the following: pH 7.4 and 6.65, conductivity 488 and 792 respectively. This can be attributed to the nature of the contaminant in the soil such as oil and other kitchen condiments which can contain higher acidic contents (oleic, benzoic acids) as stated in the proceedings of the ASTDR, 2009. Dissolved mineral contents were found in the following order: $Cl>Ca>Fe>SO_4>Mg>Cu>K>Pb>PO_3$ while heavy metals of Hg, As and Cd were found at below detectable limit range (BDL) in both the irrigated and non-irrigated soil. Total organic matter (TOM) and total organic carbon (TOC) contents were found at 91.66, 22.05 and 76.85, 179.93 in the various treatments. Chikere *et al*. (2006) in their study at Eleme petrochemical jetting port site reported a similar correlation of ions concentrations in the contaminated Eleme port soil. They revealed a higher concentration of the mineral ions in the following order 2.28, 1.84, 5.22 and 1789.22 mg/g respectively for K, nitrate, magnesium and chloride ions. Khalid *et al*. (2017) in their assessment study on soil pollution and Lead (Pb) accumulation revealed higher quotients of heavy metals like Fe, Pb and Cu in the soil while heavy metals of Hg, As, Cd were found below detectable limits in the soil. The same trend was found in the waste water as the BOD_5 quotients was found at 5.2mg/ml with initial dissolved oxygen concentrations at 6.2 mg/ml. Vallero 2010 stated that dissolved oxygen concentration (DO) is said to have reciprocal relationship with the biochemical oxygen demand (BOD) in water, he went on to state that the presence of organic matter in water bodies increases biochemical activities of aquatic flora and fauna and such leads to their exponential multiplications (Bloom) and demand for oxygen for biochemical activities (oxidation, respiration etc.). Dissolved mineral concentrations such as Cl, Ca, Mg, PO_3, Cu, Fe and SO_4 were found richly in abundance. Heavy metals such as Pb was found in trace quantity were as Cd, As and Hg were found in non-detectable range. TDS, TSS and TS were recorded at 23036, 396.5 and 23433. This as reported in the proceedings of ASTDR, 2009 that every exposed water body are characterized by the presence of solid particles which may be suspended within the costal water axis or dissolved in the olefines (horizons) of the water bed.

The proceedings went further to state that these solid particles constituents of the water can be as a result of rock weathering, human activities such as querying, volcanic eruption in the water bed and water bodies eutrophication's.

Analysis of soil enzymes showed the activity of the lipase, urease, peroxidase and catalase with corresponding OD reading of 0.403, 0.611, 0.652 and 0.817 respectively. There was an increase of lipase, urease and peroxidase after the irrigation with the waste with OD of 0.610, 0.677 and 0.712 respectively while catalase activity was reduced. Vallero 2010 reported the activities of quality marker soil enzymes in the presence of recalcitrant; most constitutive enzymes are said to be mark qualities of soil otherwise House-keeping enzymes whose activities are activated in the presence/influx of recalcitrant to a particular ecological nich(es). Lipases are activated in the presence of triacylglyceride while peroxidase and catalase activity is stimulated in the presence of peroxide and other superoxide's; urease activity is activated in the presence of organic matter urea.

CONCLUSION

The results from the present study have shown the vulnerability of agricultural soil to effluent from domestic sources used for irrigation and its impact on agricultural productivity. Despite the agronomical potentials of the waste water in composite such as abundant dissolved mineral contents (Cl, Ca, Mg, Cu, Fe), high conductivity among other benefits, there exist a reasonable amount of potential toxic element (PTE) they contain such as Pb.

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Ethics

Authors declared no ethical issues that may arise after the publication of this manuscript.

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تقييم مؤشرات الإجهاد التفاضلي في التربة الزراعية التي تستقبل مياه الصرف الصحي السائلة

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الملخص

تناولت هذه الدراسة تقييم تأثير مياه الصرف الصحي من كافتيريا جامعة نيجيريا، نسوكا على الخواص الفيزيائية والكيميائية للتربة ونشاط الإنزيمات. أظهر التحليل الفيزيائي الكيميائي للتربة قبل وبعد الري بمياه الصرف الصحي من الكافتيريا ان قيمة الرقم الهيدروجيني 7.4 و6.65 والتوصيلية 488 و792 على التوالي. تم تحديد تراكيز محتويات المعادن المذابة بالترتيب التالي: PO3<Pb<K<Cu<Mg<SO4<Fe<Ca<Cl بينما تم العثور على المعادن الثقيلة مثل Hg وAs وCd في نطاق الحد الأدنى القابل للاكتشاف (BDL) في كل من الأراضي المروية والتربة غير المروية.

وجد ان محتوى المادة العضوية الكلية (TOM) والكربون العضوي الكلي (TOC) عند 91.66، 22.05 و76.85، 179.93 في المعاملات المختلفة على التوالي بينما كان BOD5 في مياه الصرف الصحي عند 5.2 ملغم/مل مع تراكيز أولية للأوكسجين المذاب عند 6.2 ملغم/مل. تم تحديد تراكيز المعادن الذائبة مثل Cl، Ca، Mg، PO_3، Cu، Fe وSO4 بوفرة بينما لوحظ بأن بعض المعادن ثقيلة مثل Cd وAs وHg متوفرة بكميات ضئيلة جدا في نطاق غير قابل للتحديد.

تم تحديد TDS وTSS وTS عند 23036 و396.5 و23433، على التوالي. أظهر تحليل إنزيمات التربة نشاط كل من الانزيمات اللايبيز واليوريز والبيروكسيديز والكاتاليز مع قراءة OD المقابلة البالغة 0.403 و0.611 و0.652 و0.817 على التوالي. كانت هناك زيادة في قيمة OD للايبيز واليوريز والبيروكسيديز بعد الري بالمخلفات بمقدار 0.610، 0.677 و0.712 على التوالي في حين انخفض نشاط الكاتاليز.

الكلمات الدالة: الانزيمات، فيزياء كيميائية، المعادن الثقيلة، مياه الفضلات، تربة.