Effect of Grey water Soils on the Growth Rate of Maize (*Zea mays* L.) in Emohua Local Government Area of Rivers State, Nigeria

Echendu, Peter O.[1] & Nnah, Maxwell B[2].
[1] Department of Integrated Science, School of Secondary Education (Science),
Federal College of Education (Technical), Omoku'
[2] Department of Agricultural Education, School of Secondary Education (Vocational),
Federal college of education (technical), omoku
Correspondence - GSM: 0816 042 1515 / 0812 055 5244,
Email: mbnnah@yahoo.com / nnahmaxwell141@gmail.com

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Abstract

The study assesses the effect of grey water soils on the growth rate of corn (Zea maize) in Emohua Local Government Area of Rivers State. Grey water soil (GWS) and non-grey water soil (NGWS) were collected from Rumuakunda, Rumuji and Ubimini communities in Emohua Local Government Area, Rivers State. The soil samples were dried at room temperature, ground, sieved, weighed and packaged in plastic plates. The samples were digested and prepared for analysis via flame photometry, Atomic Absorption Spectrometer, and colorimetric Titrations, pH meter and conductivity meter. Levels of Boron (B), Potassium (K), Phosphorus (P), carbon (C), Sulphur (S), Chlorine (CL), Nitrogen (N), Lead (Pb)), Cadmium (cd), Chromium (Cr), Nickel (N) and Copper (Cu) were established in waste water soil and non-grey water soil. The mean values of the elements considered were higher for NGWS in Emohua Local Government Area, Rivers State, the mean values of power size, pH and electrical conductivity were higher for GWS. From these findings, grey water affects the physiochemical parameters of the soil, seed germination and plant, growth. Appropriate channels of grey water disposed should be provided by landlords and government for the inhabitants of this area.

Keywords: *Grey Water, Soil, Maize Growth and Elements*

Introduction

Grey water is a domestic waste originating from laundry, bath-room sinks, baths, showers, and in some cases, kitchen sink and dish washer waste (Maiman 2014). The composition of grey water varies and it is largely a reflection of the lifestyle and the type and choice of chemicals used for laundry, cleaning, and bathing (Nolde, 2016). However, it does not include water from toilet waste and is free of garbage – grinder residues (black water) (Ahmed & Krumpelt 2016; WHO 2016). Grey water makes up more than 70% household waste.

Grey water contains significant amounts of nutrients like nitrogen, phosphorus, and potassium (Al – Hamaiedeh & Bino, 2017). Some of the nutrients are excellent nutrient sources for vegetation when this particular form of waste water is made available for irrigation. These nutrients could be beneficial to the soil, however, reducing the amount of commercial fertilizer needed for gardens and lawns (Holtzhausen, 2015). It is a valuable resource for horticultural and agricultural growers, as well as home gardeners to benefit from. The macronutrients (nitrogen and phosphorus) in grey water in the right proportion and quantities, may serve in the same manner as fertilizer and benefit plant growth (Rodda *et al* 2016). It can also be valuable to landscape planners, builders, developers, and contractors because of the design and landscaping advantages on-site grey water treatment/management (Wood, 2018).

There is an important link between soils and water, the quality of which is closely linked to the quality of the soils (Wood, 2018). Grey water soils considered not only a rich source of organic matter and other nutrients but harbours heavy metals like iron (Fe), manganese (Mn), Copper (Cu), Zinc (Zn), Lead (Pb), chromium (Cr), nickel (Ni), cadmium (Cd), and chlorine (Cl) at high concentrations in receiving soils. However, only soluble, exchangeable, and chelated metal species in soils are mobile and hence more available to plants (Hector, 2017). The accumulation of heavy metals in edible parts of vegetables represents a direct partway for their incorporation into the human food chain because vegetables absorb heavy metals from soil, air, and water (Anderson *et al*., 2018).

Recent studies have, however, found pharmaceuticals, health and beauty products, aerosols, pigments (Eriksson, 2016), and toxic heavy metals such as Pb, Ni, Cd, Cu, Hg and Cr (Aonghusa & Grey, 2014, Erikson et al, 2016) in appreciable concentrations in grey water. The presence of these contaminants in grey water is a sign that the level of complexity in the composition of grey water is increasing over time.

There is a strong relationship between water, soil, nutrients, the germination of seeds and plant growth. Their activities are interwoven, since they are all geared towards human existence. A number of research studies have been conducted to characterize grey water at the domestic level (Eriksson, 2016). However, the major challenge is that there is still minimal and limited research information available on the typical characteristic of grey water in low income communities, as in the case of Nigeria (Carden, 2016).

The population in Emohua Local Government Area, Rivers State is experiencing steady growth, which presents challenges in managing grey water. Many older homes in the area lack the necessary plumbing for water – intensive appliances, leading home owners to dispose of their grey water on land. However, this practice carries environmental risks as grey water, although lacking human waste, contains soaps and detergents and is less sanitary than drinking water. The amount of grey water produced by households varies depending on factors such as location, income and occupancy. Developing countries often lack comprehensive policies for treating municipal water supplies, resulting in grey water that contains high levels of pollutants capable of contaminating cultivated fields and degrading soil quality. The improper disposal of grey water, which naturally seeps into the soil, is a prevalent issue. This study therefore investigates the influence on growth rate of corn (Zea mays L.) in Emohua Local Government Area, Rivers State.
The objectives of the study were to:

(i) Examine the metal contents of the grey water soils in Emohua Local Government Area, Rivers State.
(ii) Examine the metal contents of the non grey water soils in Emohua Local Government Area, Rivers State.
(iii) Assess the seed germination rate of corn (*Zea mays* L.) in grey water soil in Emohua Local Government Area, Rivers State.

(iv) Determine the growth rate of corn (*Zea mays* L.) in grey water soil and non-grey water soil in Emohua Local Government Area, Rivers State.

Materials and Methods

Sample collection and preparation:

The soil samples were randomly collected from the designated grey water soil and non-grey water soil (control samples) with a soil anger at a depth of 0 – 10cm in Emohua Local Government Area, Rivers State, Nigeria.

The areas sampled were Rumuakunde, Rumuji and Ubimini. The wet soil samples collected from each sampling site were spread on brown papers to dry at room temperature. They were then ground, sieved, weighed, and packaged in plastic plates, and labeled. The labels included the site, date of collection, and weight in grains and samples were transferred to the laboratory for further processing. The samples were subjected to digestion and analysis.

Sample analysis

The treated samples that were analyzed for heavy metal concentrations were water samples and sediment samples. The extractable heavy metals analyzed were lead, copper, chromium and cadmium.

The determination of the heavy metal contents of each sample solution and the blank were analyzed for the extractable heavy metals using Atomic Absorption Spectrophotometer (AAS). Before determination of the heavy metal concentration in each sample solution, a calibration curve of heavy metal was prepared using aliquots from standard stock solutions (Analar grade) of metal ions Pb^{2+}, Cu^{2-}, Cr^{2+} and Cd^{2-}. This was obtained by using metal salts from a mixture of commercially available 100mg/kg stock solutions.

Results

Results in table 1 shows the levels of metal of grey water and non-grey water soils in Emohua Local Government Area, Rivers State, Nigeria.

Grey water Soils:

- Potassium and Boron were higher in Rumuakunde community than the other two communities. Same level of Nitrogen was recorded for all the communities.
- Phosphorous was a little bit higher in Rumuji than the other two communities.
- Chlorine, sulphur, and organic carbon were higher in Rumuakunde community than the other two communities.
- Rumuji community accumulated more lead, cadmium and chromium than the other two communities.
- Cupper was higher in Ubimini community than the other two communities.

Non-Grey water Soils

- Potassium was not accumulated in all of the communities
- Same level of Nitrogen was recorded for the communities
- Boron, Phosphorus, Chlorine, Organic Compound, Lead and Cadmium were higher in Rumuakunde than the other two communities
- Rumuji accumulated more of chromium than the other communities.

- Cupper was seen more in Ubimini community.

Table 1: levels of metals present in grey water and non-grey water soils in Emohua Local Government Area, Rivers State, Nigeria.

	Sites in Emohua					
Mineral (Elements)	Rumuji		Rumuakunde		Ubimini	
	GWS	NGWS	GWS	NGWS	GWS	NGWS
Potassium	1.92	0.00	1.93	0.00	1.92	0.00
Boron	0.53	0.32	0.57	0.34	0.56	0.33
Nitrogen	0.07	0.02	0.07	0.02	0.07	0.02
Phosphorous	7.02	7.03	7.02	7.04	7.03	6.71
Chlorine	21.84	19.74	22.13	20.01	21.94	19.93
Sulphur	2.56	6.03	3.96	7.04	3.22	6.53
Organic carbon (%)	5.98	0.48	6.43	0.53	6.24	0.52
Lead	0.51	0.08	0.53	0.72	0.79	0.0
Cadmium	0.75	0.69	0.85	0.71	0.86	0.29
Chromium	0.95	0.79	0.98	0.69	0.99	0.82
Copper	0.63	0.89	0.41	0.51	0.54	0.54

Table 2 shows the assessment of maize (*Zea mays*) seed germination rate in grey water and non-grey water soil in Emohua Local Government Area, Rivers State, Nigeria.

Ten (10) seeds of corn (*Zea mays*) were planted in each bucket in order to investigate the effect of grey water soil on the germination maize and monitored for Twenty-one (21) days.

Day 3: In Rumuji, Rumuakunde and Ubimini more maize seeds germinated in grey water soils than in non-grey water soil.

Day 8: More maize (*Zea mays*) seed germination was recorded in grey water soil than non-grey water soil in all the three communities.

Day 13**:** All the three communities recorded more corn (*Zea mays*) seeds germinated in grey water soils than in non-grey water soil.

Table 2: shows the growth rate of corn (Zea mays) in grey water soil and non-grey water soil in Emohua Local Government Area, Rivers State Nigeria.

Days	Grey water soil (GWS) VS Non – Grey water soil (NGWS)					
	Rumuji		Rumuakunde		Ubimini	
	GWS	NGWS	GWS	NGWS	GWS	NGWS
Days 3	4	3	5	3	5	2
Days 8	5	3	6	4	6	4
Days 13	8	6	7	6	7	6

Day 8: There was higher growth rate of corn in grey water soil than in non-grey water soil in all communities.

Day 14: There was higher growth rate of corn (Zea mays) in grey water soil than in non-grey water soils in all the communities.

Day 21: There was higher growth rate of corn (Zea mays) in grey water soil than in non-grey water soil in all communities.

This implies that grey water generated in Emohua a Local Government Area contain nutrients that are beneficial to the growth of corn. Therefore, it indicates that grey water soil, with respect to maize seedlings in this research is a better soil than non-grey water soil.

DAYS	Rumuji		Rumuakunde		Ubimini	
	GWS	NGWS	GWS	NGWS	GWS	NGWS
DAYS 8	1.4	0.6	1.4	0.6	1.5	0.6
DAYS 14	1.8	1.1	1.7	1.2	1.8	1.3
DAYS 21	2.7	1.5	2.7	1.5	2.7	1.4

Discussion

Elemental Properties of Soil Sample in Emohua Local Government Area

The findings on chemical properties revealed the quantity of potassium in greywater soil and non-greywater soil in Ubimini, Rumuakunde and Rumuji. From the analysis, the quantity of potassium in greywater soil in Oduha was 1.927mg/l, Rumuakunde and Rumuji was reported to be 1.913 mg/l and that of non-greywater soil showed the absence of potassium in all the sampled locations in Emohua Local Government Area. The mean values obtained from boron analysis of the greywater soil were observed at 0.530mg/l, 0.570 mg/l, and 0.560mg/l for Ubimini, Rumuakunde and Rumuji, whereas those of the non-grey water soils were 0.317mg/l, 0.340mg/l, and 0.33mg/, respectively. This result implies that the grey water soil contains a higher quantity of potassium and boron than the non-grey water soil, and could be attributed to the components of the grey water disposed. In a similar development, the nitrogen mean values of grey water soil in Ubimini, Rumuakunde and Rumuji were estimated at 0.07mg/l, while for non-grey water soil, it was 0.015mg/l for Rumuji and 0.020mg/l for Ubimini and Rumuakunde. This finding is corroborated by the ideas of Arvind *et al.* (2019). They estimated a high content of potassium and boron in soil and solid waste sites. Consistent with this study is the high level of boron in grey water samples characterized by Prabhakar *et al.* (2019).

The mean values of phosphorous in grey water soil and non-grey water soil were relatively equal at a range value of 7.017-7.040mg/l for the entire location sample, except for Rumuji, with a lower mean value of 6.703mg/l on non-grey water soil. This could be attributed to the type of grey water used on the soil. The results further reveal the mean value of chlorine in grey water soil and non-grey water soil. For Ubimini, Rumuakunde and Rumuji, the chlorine mean value of grey water soil was estimated to be 21.843 mg/l, 22.127mg/l, and 21.940mg/l, while the non-grey water soils were observed at 19.747mg/l, 20.010mg/l, and 19.930mg/l. The findings revealed that grey water soil contains more chlorine than non-grey water soil, and could be associated with increases in the chlorine content of grey water. The high value of chlorine could be associated with domestic waste water and other sources of chlorinated water on the soil (Lazarova & Bahri, 2005).

The analysis of sulphur content showed that grey water soils contain less sulphur than non-grey water soils. The samples of Ubimini, Rumuakunde and Rumuji have the mean values of sulphur as 2.557mg/l, 3.953mg/l, and 3.220mg/l for grey water soil, whereas for non-grey water soil, the mean values were estimated at 6.027 mg/l, 7.033mg/l, and 6.523mg/l. This is an indication that the grey water disposed of on the soil was able to reduce the sulphur component of the soil.

The organic carbon found in the grey water soils was higher than that found in the non-grey water soil. The mean values of organic carbon of grey water soils from Ubimini, Rumuakunde and Rumuji were 5.980mg/l, 6.430mg/l, and 6.233mg/l, whereas those of non-grey water soils were 0.477mg/l, 0.530mg/l, and 0.513mg/l. This implies that the grey water contains high levels of organic carbon from sewage systems and other domestic waste water that may have impacted the soil (Prabhakar *et al*. 2019).

The lead content of grey water soil was higher than that of non-grey water soil. The lead mean values for Ubimini, Rumuakunde and Rumuji grey water soil were 0.506 mg/l, 0.523 mg/l, and 0.781mg/l, whereas those of the non-grey water soil were 0.078 mg/l, 0.072 mg/l, and 0.063 mg/l. This increase in the mean values could be associated with the high content of lead in the grey water used in various sampled areas. From the findings, the mean value of astatine in grey water soil was higher than that of non-grey water soil. The mean values of astatine for Ubimini, Rumuakunde and Rumuji were observed to be 0.602mg/l, 0.657 mg/l, and 0.873 mg/l, while those of non-grey water soils were 0.220 mg/l, 0.229mg/l, and 0.287mg/l. The increase in the mean values could be attributed to the presence of substances that contain lead in the grey water deposited. The findings of Bulnes and Garduno (2009), who studied grey water from various sources, were consistent with this observation. As one of their findings, in-line with Carden *et al*. (2006), grey water soured from kitchens and urine has a high level of nitrogen.

The cadmium analysis indicates that the grey water soil obtained from Ubimini, Rumuakunde and Rumuji has higher cadmium levels than the non-grey water soil. The mean value of cadmium in the grey water soil was observed to be 0.749 mg/l, 0.849 mg/l, and 0.851 mg/l for the three sampled areas, while the non-greywater soils had their mean values of 0.697 mg/l, 0.703mg/l, and 0.687 mg/l. The mean values of grey water soils from Ubimini, Rumuakunde and Rumuji were 0.950 mg/l, 0.979 mg/l, and 0.990mg/l, while those of non-grey water soils were 0.790mg/l, 0.812mg/l, and 0.877mg/l. The result implies that the chromium content in grey water soil was high, which is attributed to the source of the grey water. Further analysis of the copper content in grey water soil showed that the soil obtained from Ubimini, Rumuakunde and Rumuji has a high mean value of 0.623mg/L, 0.534mg/L, and 0.505mg/L, while the non-grey water soils have mean values of 0.533mg/L, 0.404mg/L, and 0.380mg/L. The relative increase in the mean values was associated with the type and source of the grey water deposited on the soils (Warne, 1995; Warne & Schifko, 1999; Lens, & Lettinga, 2001).

Analysis on Emergence of seed (ES) of GWS in Emohua Local Government Areas:

The "Seed emergence" is the number of seeds that sprout out in a given period of time. Ten corn seeds were planted and monitored for three weeks in both grey water soil and non-grey water soil collected in Emohua local government areas in Rivers State. The result from the seed emergency analysis revealed that the mean of corn seed emergence of grey water soil obtained from Ubimini, Rumuakunde and Rumuji were 4.889, 5.444, and 5.222, while those of non-grey water soil 2.778, 3.444, and 3.111. The finding implies that the nutrients in the grey water soil were able to enhance the emergence (germination) of corn seed, and also, the grey water soils are better than the non-greywater soil in respect to corn seed germination. The finding also shows that greywater soil of Rumuakunde has the highest corn seed germination, while that of Ubimini has the least germination. In corroboration with the findings is the investigation of Ikhajiagbe *et al.* (2017) on the germination of okra seed, Ikhajiagbe *et al.* (2017) on the germination of fluted pumpkin, and Saeed *et al.* (2015) on the germination of *Sesbania grandiflora L.* Their observations indicated positive germination of the respective seed in irrigated greywater rather than fresh water.

Analysis of the Height of developed seedling in grey water soil and Non- grey water soil in Emohua Local Government Area:

The investigation of the growth rate of corn plants in grey water soil and non-grey water soil in Emohua Local Government Areas shows that the grey water soil supports corn plants better than the non-grey water soil. The growth rate analysis implies that the increase in the number of days increases the height of the plant. The mean growth rates for grey water soil in Ubimini, Rumuakunde and Rumuji were 1.978cm, 1.989cm, and 1.967cm, while those for non-grey water soil were 1.083cm, 1.106cm, and 1.073cm. This is an indication that the grey water soil in Emohua is better than the non-grey water soil and could be used in the cultivation of maize.

The increased growth rate of maize could be attributed to the high nutrient content associated with grey water soil in the area sampled. This finding is consistent with Ikhajiagbe *et al.* (2017), who investigated the root and leaf development of plants on wet soil. They observed that the presence of grey water nutrients impacts root and leaf development. A similar report by Anwar *et al.* (2011), and Samayamanthula *et al.* (2019), was in line with the findings of this research, where waste water was reported to enhance the growth rate of plants.

Summary

The study on Effect of grey water and non grey water soils on the growth rate of maize plants was carried out in Emohua local government area of rivers state. Six objectives guided the study. The review was organized under the background and empirical studies. Grey water is seen as domestic waste gotten from laundry, bath-room sinks, baths, showers, and, in some cases, kitchen sink and dishwasher waste. The composition of grey water varies, and it is largely a reflection of the lifestyle and the type and choice of chemicals used for laundry, cleaning, and bathing.

The research adopted an experimental design, since the activities took place in the laboratory. eighteen different samples, made up of nine grey water soil and nine non-grey water soil, were collected from Emohua Local Government Area. The areas sampled were Ubimini, Rumuakunde and Rumuji. The samples were prepared for elemental properties. The elements considered were potassium, boron, nitrogen, phosphorous, chlorine, organic carbon, sulphur,

lead, cadmium, chromium, and copper. The AAS, UV-VIS, weighing balance, and others were used to obtain the data for this study. The data, however, were analysed using a mean/standard deviation, and an independent t-test.
The findings of the study were summarized below;

1. For the elemental analysis in Emohua, the values of potassium, boron, nitrogen, chlorine, organic carbon, lead, cadmium, chromium and copper were higher in the grey water soil than the non-grey water soil while sulphur and phosphorous were higher in the non-grey water soil than the grey water soil
2. The finding revealed that the maize seed germinated more in grey water soil than the non-grey water soil within the sampled area considered in Emohua local government of Rivers State.
3. The result also show that the growth rate of the germinated maize seeds were better in grey water soil than the non-grey water soil.

Conclusion
Based on the findings regarding the comparative analysis of the elemental properties of grey water and non-grey water soils in Emohua Local Government Area of Rivers State, The grey water soil and the non-grey water soil contain the same elements; potassium, boron, nitrogen, chlorine, organic carbon, lead, cadmium, chromium, copper, sulphur, and phosphorous, but with different concentrations or values. However, the concentrations of all the elements identified are higher in the grey water soil, except for sulphur, with a lower concentration.

The grey water soils in Emohua Local Government Areas have better seed emergence and growth rates on the number of days considered when compared with the control. This is based on the number of maize seeds that germinated and the height of the measured plants at a given number of days.

Recommendations
Based on the Comparative analysis of the elemental properties of grey water and non-grey water soils in Emohua Local Government Area of Rivers State, the following recommendations have been made:

2. The Environmental Protection Agency in Emohua Local Government Areas of Rivers State should include grey water as part of those substances that contribute to environmental soil nutrients, because of the presence of chemical elements.
3. Landlords should make appropriate provisions for disposing of grey water and ensure that rules and regulations on grey water disposal are obeyed.
4. On the basis of the rapid germination of maize seedlings in greywater soil in Emohua Local Government Areas in Rivers State, which could be associated with the presence of micro and macronutrients, maize seedlings should be cultivated on greywater soil.
5. Agriculturists should plant on grey water soil because of the rapid growth rate of maize seeds, as this will improve maize production and reduce market costs.

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