International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 4, May-June 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Effect of Untreated Brewery Wastewater on the Physicochemical Properties of Agricultural Soil and Crop Yield

Mbonu, C. F.*; Onuorah, S. C.; Anaukwu, C. G.

Department of Applied Microbiology and Brewing, Nnamdi Azikiwe University, Awka, Nigeria

ABSTRACT

The increasing rate of environmental pollution especially of water bodies due to discharges from industries has become a serious challenge. Wastewater reuse is a useful tool in minimizing the amount of effluent discharge into the environment. This research was conducted to evaluate the effect of untreated brewery effluent on the physicochemical of soil and crop yield. The physicochemical properties of untreated effluent from a brewery and its effects on soil physiochemical properties and maize crop yield, were studied using standard analytical methods. The potential of brewery effluent as a nutrient source for crop production was assessed through pot culture experiments. The effluent was found to be slightly acidic in nature, and had high BOD and COD due to the presence of large amounts of solids. The effluent was rich in nitrate, phosphate and potassium, so that its application to the soil increased the values of available nutrients in the soil. The pH of the soil decreased gradually with increasing concentration of the effluent. The brewery effluent increased the moisture content and plant nutrients of the irrigated soil.

In the pot culture studies, the growth parameters such as plant height, number of leaves, root length, fresh and dry weight, number of seeds per cob and the total chlorophyll content of the maize plants were measured. The growth of the maize plant was highest with 100% untreated effluent but low in productivity, while its productivity was highest with 50% effluent. The heavy metals content of the harvested maize analysed were all within permissible limit. This research revealed that brewery wastewater reuse in agriculture at 50% is an efficient tool for pollution control as well as improved soil properties and crop yield.

KEYWORD: *Brewery wastewater, crop yield, irrigation, physicochemical properties, soil, untreated*

How to cite this paper: Mbonu, C. F. | Onuorah, S. C. | Anaukwu, C. G. "Effect of Untreated Brewery Wastewater on the Physicochemical Properties of Agricultural Soil and Crop Yield" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-4, June 2022, pp.1146-1157, URL: www.ijtsrd.com/papers/ijtsrd50203.pdf

IJTSRD50203

1. INTRODUCTION

Wastewater is any water that has been affected by human use. It is used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff or storm-water, and any sewer inflow or sewer infiltration (Tilley *et al*., 2014). Wastewater is an inevitable consequence of industrial processes. Industries use water during during production process for either creating their products or cooling equipment and or washing of equipment used in products creation. The brewing industry is one of the largest industrial users of water (Kundu *et al.,*2013*)* the brewing process produces a significant amount of wastewater. Even with technological improvements, it has been found that for every 1 liter of beer produced (about 40 fluid ounces), between 3 and 10 liters (1 to 2.5 gallons) of waste effluent is generated (Kanagachandran and Jayaratne, 2006).The improper management of this waste has become one of the most critical problems of developing countries (Navarro *et al*., 2019).

The disposal of wastewater is a major problem faced by industries, due to generation of high volume of effluent and with limited space for land-based treatment and disposal. The quality of brewery effluent can fluctuate significantly as it depends on the various different processes that take place within the brewery (Samuel *et al.*, 2014) The components of brewery effluent are water, sugars, soluble starch, ethanol, volatile fatty acids as well as solids which are mainly spent grains, waste yeast and tub (Driessen and Vereijeken, 2003). Brewery effluent, when discharged into the environment, poses a serious health hazard to the rural and semi-urban populations that use water from stream and river for agriculture and domestic purposes, with reports of fish mortality and damage to the paddy crops (Samuel *et al.*, 2014). On the other hand, wastewater is also a resource that can be applied for productive uses since it contains nutrients such as the nitrogen, potassium, phosphorus etc. that have the potential for use in agriculture, aquaculture and other activities (Hussain *et al.,* 2001).

Water and nutrients are the most important factors for crop production and their management is more challenging due to their scarcity and high cost. Their efficient use is indispensable for sustainable agriculture in view of the shrinking land, water, increasing fertilizer prices, wide spread pollution and fast degradation and depletion of natural resources. Thus, there is a need to develop eco-friendly measures to utilize liquid wastes profitably (Driessen and Vereijeken, 2003). Since the production of wastewater is a continuous process, it can cater for substantial agricultural requirements. Brewery effluent containing some organisms and organic elements necessary for plant growth can serve as a potential source of nutrients for agricultural purposes. Agricultural use of wastewater, therefore, might represent a unique opportunity to solve the problems of pollution, water and nutrients supply for agriculture, improvement of soil quality and also reduction of waste treatment and disposal cost.

This study determined the physicochemical parameters (pH, temperature, electrical conductivity, turbidity, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, chloride, phosphate, sulphate, nitrate, potassium, total solids, total dissolved solids, total suspended solids, moisture contents) of the untreated effluent and soil samples before and after irrigation, assess the heavy metals content (iron, lead, copper, chromium, cadmium and nickel) of the effluent and soil before and after irrigation and that of the harvested maize, study the impact of the untreated brewery effluent on the yield of maize by measuring the number of leaves, plant heights, root length, fresh and dry weight of the maize seed, number of seeds by cob and chlorophyll contents of the leaves of the maize plants. The findings from this study will help to solve the basic problem of water and soil pollution to a great extent, once this nutrient rich effluent is established as an economically feasible and eco-friendly resource for use in agriculture, thereby converting waste to wealth.

2. MATERIALS AND METHODS

2.1. Study area

The study area for this research is Onitsha, located on the Eastern Bank of the River Niger, Anambra State Nigeria. It is a metropolitan city, known for its river port and it is an economic hub for commerce, industry and education. It hosts the Onitsha Main Market, the largest market in Africa with a population of 1,109,300 as of 2015 and estimated to be 1,863,419 in 2021 (UNDESA,2018). The climate is influenced by two major trade winds: the warm moist south-west trade winds during the rainy season (April–October) and the north-east trade winds during the dry and dusty harmattan (November–March). The temperatures are generally high, between 25 and 27 degrees Celsius, with maximum temperatures experienced in the December–March period and minimum temperatures in the June–September period. Annual rainfall averages about 1,850 millimetres (74 inches) per annum, which is reasonably high. Most of the rain falls between mid-March and mid–November. Rain in the dry season is infrequent. The vegetation of this region is light forest interspersed with tall grasses. The trees are not too tall and include both hardwood and softwood varieties. Domesticated trees such as the mango, palm tree, guava, orange, and almond are found. Much of the natural vegetation has been deforested and the land utilized for development.

2.2. Sample collection

2.2.1. Collection of untreated brewery effluent for physicochemical analyses

Untreated brewery effluent from Intafact Beverages Ltd. Onitsha, Anambra State Nigeria, was collected using 1 litre capacity container. The sample containers were washed thoroughly and rinsed with distilled water. They were thereafter rinsed with the effluent several times before collection. The pH and temperature of the samples were measured using pH meter and thermometer respectively at the collection point. The samples were transported to Projects Development Agency (PRODA) Enugu for physicochemical analyses.

2.2.2. Collection of untreated brewery effluent for irrigation.

Untreated brewery effluent was collected using 10 litres plastic containers with stopper on weekly basis. Prior to sample collection, the sampling cans were thoroughly washed using sterile water, sun-dried and rinsed with the same effluent to be collected.

2.2.3. Soil sample collection

The soil sample for the field experiment was collected using a sterile soil auger at a depth of 15 cm into a sterile sample bag from an aagricultural farm Onitsha, Anambra state.

2.2.4. Maize seed collection

Sweet corn seeds were purchased from the Federal Ministry of Agriculture Awka, Anambra State and sorted based on morphological observations such as size and absence of pest infestations as described by Thapa (1994).

2.3. Physicochemical analysis of the untreated effluent samples.

The following physicochemical parameters of the effluent sample were analysed: pH, temperature, electrical conductivity, turbidity, total dissolved solids, total suspended solids, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, chloride, phosphate, sulphate, nitrate, potassium, total solids, iron, lead, copper, chromium, cadmium and nickel. The evaluations were carried out using standard analytical methods described by APHA (1998) and Adelowo (2016).

2.3.1. pH

The pH of the sample was determined using pH meter (Mettler Toledo pH meter) *in situ*. The pH of the effluent sample was measured by dipping the pre-calibrated pH meter into 10ml of the effluent in a 20ml beaker.

2.3.2. Temperature

Temperature of the samples was recorded using the thermometric method in-situ (at the site of sampling) by the use of calibrated mercury thermometer.

2.3.3. Electrical conductivity

The conductivity of the effluent sample was measured by dipping the electrode of the conductivity meter (Mettler Toledo Conductivity Meter) into 20ml of the effluent in a 50ml beaker and the reading was taken after stabilization.

2.3.4. Turbidity

The turbidity of the effluent sample was determined using a turbidity meter manufactured by LabScience Tamil Nadu, India. The meter was initially calibrated to the zero point. The sample was homogenized and introduced into the sample bottle and placed inside the reading chamber and covered with the chamber lid. Turbidity reading was taken after 10 seconds and expressed as Nephelometric Turbidity Unit (NTU).

2.3.5. Total solids

Total solids of the effluent sample were estimated using Gravimetric method. 100 ml beaker was sterilized by oven drying at 105^0C for 6hrs and cooled in a desiccator. The weight of the empty beaker was noted before use. The sample was homogenized and 50ml measured using a sterile measuring cylinder. The sample was transferred into the weighed beaker, heat-dried in the oven at 105^0 C and cooled in the desiccator and the weight measured.

Calculation

$$\text{Total solids (mg/l)} = \frac{(w_2 - w_1) \times 1000}{\text{Vol. of sample}}$$

Where w_1 represents weight of beaker before use and w_2 represents weight of beaker after use.

Total dissolved solids

The total dissolved solids content of the effluent sample was measured using the Gravimetric method. The weight of the dried filter paper was noted. The sample was homogenized and 50ml measured using the sterile measuring cylinder, after which the sample was filtered using dried filter paper. After the filtration, the filter paper with the residue was dried in the oven, cooled and the weight taken.

Calculation

$$\text{Total dissolved solids (mg/l)} = \frac{(w_2 - w_1) \times 1000}{\text{Vol. of sample}}$$

Where w_1 represents weight of filter paper before use and w_2 represents weight of filter paper after use.

Total suspended solids

Suspended solids were determined from the difference between the total solids and dissolved solids as follows;

TS mg/l – TDS mg/l =T SS mg/l

Where;
TS = total solids
TDS = dissolved solids
TSS = suspended solids

Dissolved oxygen

Dissolved oxygen was determined using dissolved oxygen meter manufactured by Hanna Instruments, USA. The meter was calibrated using open air calibration method as described by the manufacturer. The meter probe was inserted into the container containing the effluent sample and the dissolved oxygen content was measured in mg/l.

Biochemical oxygen demand

Dissolved oxygen in the fresh effluent sample was determined using dissolved oxygen meter, after which the sample was stored in laboratory amber bottles in the dark at room temperature for five days. Dissolved oxygen was determined in the samples again after the fifth day. Biochemical oxygen demand was taken as the difference in the initial value of dissolved oxygen and the final value of dissolved oxygen after five days.

$BOD_5 = DO_0 - DO_5$

Chemical oxygen demand (COD)
Five milliliters of 0.025N potassium dichromate ($K_2CR_2O_7$) were added into 10ml of the effluent sample, followed by addition of 15ml of conc. sulphuric acid (H_2SO_4). The solution was diluted with 40ml of distilled water to get 70ml solution. Seven drops of phenanthroline ferrous sulphate indicator were added giving a greenish colour. The solution was allowed to cool and then titrated with 0.025N ferrous ammonium sulphate and observed for colour change from greenish blue to orange. The same procedure was carried out for blank.

Calculation:

$$\frac{[(T1-T2) \times N \times 8000 - C]}{\text{Vol of the sample used}} \text{ mg/l}$$

Where:
T1= titre value for blank
T2= titre value for effluent sample
N= normality of the ferrous ammonium sulphate used which is 0.025
C= chloride correction (milligram per litre chloride x 0.23)

Chloride
Chloride was obtained using Argentometric titration method**.** Potassium chromate indicator solution was prepared by dissolving 50g K_2CrO_4 in a distilled water and $AgNO_3$ solution was added until a definite red precipitate was formed. This solution was allowed to stand for 12 h, filtered and diluted to 1litre with distilled water.

2.395g $AgNO_3$ was dissolved in distilled water and diluted to 1000 mL and stored in a brown bottle. This is the Standard silver nitrate solution.

50ml of the effluent sample was measured into 250ml conical flask,1ml K_2CrO_4 solution(indicator) was added and titrated with $AgNO_3$(titrant) to a pinkish yellow end point. The process was repeated for blank using 50 ml of distilled water.

Calculation: $\text{Mg } Cl^-/L = \frac{(A-B) \times N \times 35 \times 450}{\text{ml of sample}}$

where: A = ml titration for sample, B = ml titration for blank, N = normality of $AgNO_3$

Phosphate
The method described by Adelowo (2016) was used to determine the total phosphate in the effluent samples. 15mls of effluent were dispensed into a clean curvette, 3ml of ammonium molybdate and 2ml of hydrazine sulphate were added. The mixture was kept in a water bath for 30mins and thereafter read using the Spectrophotometer at 690nm.

Concentration of phosphate in the effluent samples was calculated from the equation:

$$\frac{\text{Absorbance of sample} \times \text{concentration of standard}}{\text{Absorbance of standard}}$$

Sulphate
10ml of the effluent sample were decanted into a clean curvette. 1ml of 95% isopropyl alcohol, 0.5ml of glycerol and 5ml of conditioning reagent which consisted of Nacl, Bacl and Citric acid were added to the curvette containing the sample. The solution was left to stand for 5mins to allow colour development, after which the absorbance was read at 420nm wavelength using a Spectrophotometer.

Nitrate
10ml of the effluent sample were introduced in a test tube, followed by the addition of 2ml Nacl solution. The mixture was swirled and 10ml of H_2S0_4 solution were also added. The resultant solution was swirled and allowed to stand. A sample blank was also prepared. To the first tube containing the mixture of the effluent, NaCl and H_2S0_4, 0.5ml of brucine-sulphanic acid reagent were added and the test tube was allowed to develop color and the absorbance reading of the solution at 410nm was taken using a Spectrophotometer. Concentration of nitrate was calculated following the equation:

$$\frac{\text{Absorbance of sample} \times \text{concentration of standard}}{\text{Absorbance of standard}}$$

Potassium
Two milliliters effluent sample were introduced into 1.5ml concentrated nitric acid and diluted with distilled water, filtered through a whatman filter paper into a 100 ml volumetric flask and subsequently made up to the mark (100ml) using distilled water. The potassium content of the effluent was read using Atomic Absorption Spectrophotometer manufactured by Buck Scientific, USA.

Heavy metals analysis of the effluent samples
The method described by APHA (1998) was used to determine the heavy metals content (iron, lead, copper, chromium, cadmium and nickel) of the effluent. 2ml effluent sample were introduced into 1.5ml concentrated nitric acid and diluted with deionized distilled water, filtered through a whatman filter paper into a 100 ml volumetric flask and subsequently made up to the mark using distilled water. Metal concentration (iron, lead, copper, chromium, cadmium and nickel) were analyzed using Atomic Absorption Spectrometer manufactured by Buck Scientific, USA.

PHYSICOCHEMICAL ANALYSIS OF THE SOIL SAMPLES BEFORE AND AFTER IRRIGATION

Physicochemical analysis was carried out on the soil sample before and after irrigation. The parameters evaluated were pH, electrical conductivity, chloride, phosphate, sulphate, nitrate, potassium, moisture, iron, lead, copper, chromium, cadmium and nickel. The evaluations were carried out using standard analytical methods described by APHA (1998).

Moisture

Five grams of each of the soil sample were weighed into an already weighed Petri dish. The sample in Petri dish was transferred into an oven and dried for an hour at 105^0C. The sample was thereafter allowed to cool in a desiccator and weighed. Percentage moisture was calculated as follows:

$$\% \text{ Moisture} = \frac{a - b}{b} \times 100$$

Where a = weight of the moist soil, b = weight of the dry soil.

FIELD EXPERIMENT

Maize planting was carried out using pot experiment method as described by Tai (1996). The effluent sample was used as irrigation water to monitor the effect of the effluent on growth and maize yield.

Seed and Soil preparation

The maize seeds were cleaned with 0.2% ethyl alcohol and washed three times with distilled water to remove seed pathogens and alcohol. The soil sample was sieved to remove debris.

The experimental set up

Seven treatment sets labeled 0%W, 5%W, 15%W, 25%W, 50%W, 75%W and 100%W each consisting of three replicates were set up. Twenty-one plastic buckets were each filled with 5kg of the prepared soil samples. The control set up (0%W) was treated with tap water while the other treatment sets were treated with different concentrations of the effluent sample (5%, 15%, 25%, 50%, 75%, and 100%).

Preparation of the various concentrations of the effluent

Different effluent concentrations were prepared as described by Mahalingam *et al*. (2014). The untreated brewery effluent sample was considered as 100% concentration. Other concentrations were prepared by diluting the effluent with appropriate volume of tap water to make 100ml.

Effluent dilution patterns used for crop irrigation

0%W: 0% effluent - 100% tap water (control)

5%W: 5% effluent - 5 ml of effluent + 95 ml of tap water.

15%W: 15% effluent - 15 ml of effluent + 85 ml of tap water.

25%W: 25% effluent - 25 ml of effluent + 75 ml of tap water.

50%W: 50% effluent - 50 ml of effluent + 50 ml of tap water.

75%W: 75% effluent - 75 ml of effluent + 25 ml of tap water.

100%W: 100% effluent – 0% tap water.

PLANTING AND IRRIGATION

The maize seed was planted into the soil contained in the experimental bucket. Five hundred milliliters of the different effluent concentrations were sprinkled into their respective setups twice a week for a period of twelve weeks.

Vegetative growth parameters

The vegetative growth parameters of the maize plant were measured during and after the growth period. Number of leaves and plant height were measured on a weekly basis, while chlorophyll, root length, number of seeds per maize cob, fresh and dry weight of the maize were measured after the growth period.

Plant height

The height of the maize plant was measured in centimeter from the soil surface to the highest point of the arch of the uppermost leaf whose tip was pointing down using a measuring tape as described by Rocquigny (2019).

Number of leaves

Leaf over method as described by Rocquigny (2019) was used to determine the number of leaves. The number of leaves starting from the lowest to the last leaf that had arched over (tip pointing down) was counted and noted.

Chlorophyll content

Chlorophyll analysis was done according to the method of Kamble *et al*. (2015). One gram of leaf sample at 8weeks of growth was finely cut and grounded with a clean pestle and mortar. 20ml of 80% acetone and 0.5gm $MgCO_3$ powder were added to the homogenized leaf material. The materials were further ground gently. The sample was then put into a refrigerator at 4^0C for 4 hours. Thereafter, the sample was centrifuged at 500 rpm for 5 minutes. The supernatant was transferred to 100 ml volumetric flask. The final volume was made up to 100 ml with addition of 80% acetone. The color absorbance of the solution was estimated by using a Spectrophotometer at 645 and 663nm wavelength against the solvent. Acetone (80%) was used as a blank.

Formula:
$Chl\ a = 11.75 \times A_{662.6} - 2.35 \times A_{645.6}$
$Chl\ b = 18.61 \times A_{645.6} - 3.96 \times A_{662.6}$

Where, Chl a and Chl b are the chlorophyll a and Chlorophyll b, A is absorbance.

Fresh and dry weight of the maize seeds
The fresh and dry weight of maize were determined as described by Mahalingam *et al.* (2014). The weights of the fresh maize were taken and recorded as the fresh weight of the maize. It was further dried in a hot air oven at 80°C for 24 hours, weighed again using a weighing balance and recorded as dry weight.

Number of seeds
The number of seeds per maize cob was counted following the method of Rocquigny (2019). The seeds per maize cob were carefully removed and placed into a clean plate. The seeds were counted and recorded.

Root length
This was determined as described by Mahalingam *et al.* (2014**).** The root length of the plants was measured after harvesting. The soil sticking to the roots was washed away and root samples were thoroughly washed with distilled water and dried using tissue paper. The root lengths were measured with a meter rule in centimeter.

Heavy metal analysis of the harvested maize samples
One gram of each maize sample harvested from different soil treatments was accurately weighed into a porcelain crucible. 2 ml of concentrated sulphuric acid were added to the weighed sample and subsequently heated on a heating hot plate until the whole content dried up. 1.5 ml of nitric acid was each added to the various maize sample in drop-wise manner to prevent the sample from splashing and foaming. The dried samples were then subjected to a two-stage muffle furnace heating program until completely ashed (450 ^{0}C for 2 h and 550 ^{0}C for another 2 h). The resulting sample were introduced into 1.5ml concentrated nitric acid and diluted with deionized distilled water, filtered through a whatman filter paper into a 100 ml volumetric flask and subsequently made up to the mark using distilled water. Metals (iron, lead, copper, chromium, cadmium and nickel) concentration were analyzed using Atomic Absorption Spectrometer manufactured by Buck Scientific, USA.

RESULTS AND DISCUSSION

Physicochemical Analysis of the untreated brewery effluent.
The pH, temperature, electrical conductivity, turbidity, total solids, total dissolved solids, total suspended solids, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, chloride, phosphate, sulphate, nitrate and potassium, of the samples were analyzed and results obtained are shown in Table 1. Different concentrations of heavy metals were detected from the effluent sample as also shown in Table 1. The pH value obtained was slightly higher than the neutral pH of water. This could be due to detergents used for washing the equipment that constituted part of the brewery wastewater. However, the value is within the permissible standards of WHO (2006) and FAO (1994). Similar result was recorded by Ogbu *et al.* (2016), while evaluating the physicochemical characteristics of Ama Brewery effluent and its receiving Ajali River in Udi, Enugu State, Nigeria.

The temperature of 29^{o}C obtained in the study was within the standards for effluent re-use and it met the WHO (2006) and FAO (1994) guideline values. This result is in line with Alao *et al.* (2010) and Olorode and Fagade (2012) who reported 24– 29°C temperature range. The turbidity of the effluent used in this study was above WHO (2006) and FAO (1994) standards. A possible reason for the murky appearance of the effluent discharge may be as a result of industrial food processing stages during brewing, which comprises of machine and bottle cleaning wastes, wastes from raw materials processing and other down-stream processing wastes. It is in line with the work of Olowookere *et al.* (2018) who reported turbidity range of 7.93-188.55NTUs. High turbidity may not have any negative effects on agriculture but may pose danger to the irrigation facility as reported by Olowookere *et al.* (2018).

The dissolved oxygen (DO) values obtained in this study was above the above WHO (2006) and FAO (1994) limits but was similar to value obtained by Okoye *et al.* (2011) for effluents discharged by soap factories in Aba.

The five days biological oxygen demand (BOD5) of the brewery effluents recorded in this study was within WHO (2006) and FAO (1994 permissible standards for effluent re-use in irrigation.

The study showed high concentration of nitrate, sulphate and phosphate which could have emanated from putrefaction of proteins and other organic materials and is in line with the work of Ibekwe *et al.* (2004).

The total suspended solids of the brewery effluent were above the permissible limits The presence of high level of total suspended solids and total dissolved solids might be due to the insoluble organics such as mash, spent grains, waste yeast, spent hops, grit and inorganic matter present in the effluent as reported by Nagarajan *et al.*(2010). The values may not have any negative effect on the soil and crop yield as high TSS often means high concentrations of microorganisms, nutrients or inorganic chemicals. Total dissolved solids recorded in this study showed that the value was within the permissible standards of WHO (2006) but above FAO (1994) standard.

Some of the high physicochemical characteristics of the brewery effluent obtained in this study is in line with the reports of Egwuonwu *et al*. (2012) and also corresponds with the work of Kowsalya *et al*. (2010) who worked on physico-chemical characterization of brewery effluent.

iron, lead, copper, and nickel were found to be within the maximum permissible level set by FAO (1994) and WHO (2006) while chromium and cadmium were above the maximum permissible limits.

Table 1 here

Physicochemical analysis of the soil samples before and after irrigation.

The results of the physicochemical analyses of the unpolluted and polluted soil are presented in Table 2.

The pH, conductivity, chloride content, phosphate content, sulphate content, nitrate, potassium and moisture content of the samples ranged from 6.03 – 7.9, 2.20 – 3.971ds/m, 90 - 284mg/kg, 0.73 – 58.4mg/kg, 7.56 – 13.82mg/kg, 33.09 – 502.4mg/kg, 5.27 – 37.48mg/kg, 51.97-65.33 respectively. Different concentrations of heavy metals were detected from the soil samples. The pH of the treated and untreated soil samples ranged from 6.3 to 7.9. Oshunsanya (2018), posited that the best soil pH value for growth of agricultural crops is 5.5 – 7.5. With increasing concentration of the effluent in the soil, the pH of the irrigated soils reduced. Nickel, chromium and cadmium were found to be above the maximum permissible level set by FAO (1994) and WHO (2006) while iron, lead and copper were within the standard permissible limits. Halilu and Ahaneku (2010) noted that these metals may accumulate in soil and impact negatively on plant life when present in high concentrations, while Senthilraja (2013), posited that certain crops possess the ability to degrade/utilize such high concentrations when they are applied from the concept of phyto-remediation.

It was observed that there was no significant ($p>0.05$) decrease in maize crop yield across the different irrigated groups, from week 6 to week 12. This finding agreed with the position of Senthilraja (2013), that maize crops possess the ability to utilize brewery effluent for growth. Brewery effluent contains plant nutrients and trace elements, which are utilized for better crop yield (Lenin and Thamizhiniyan, 2009). This finding is in conformity with the reports of Sumathi *et al.* (2006).

Table 2: Physicochemical parameters of the soil before and after irrigation of different concentrations of effluent

Parameter	Soil						
	Co	5%	15%	25%	50%	75%	100%
pH	7.9	7.50	7.41	7.36	7.24	6.43	6.30
Conductivity (ds/m)	2.20	2.36	2.66	2.8I	3.16	3.49	3.971
Chloride (mg/kg)	90.8	94	108	119	135	186.6	284
Phosphate (mg/kg)	58.4	73	109	123	159	178	194
Sulphate (mg/L)	7.56	9.29	10.16	10.63	12.3	13.59	13.82
Nitrogen	33.09	72.5	82.4	140.8	265.6	398.4	502.4
K (mg/l)	5.27	8.43	13.77	19.96	27.21	32.06	37.48
Moisture	21.97	53.04	58.86	61.21	62.58	64.44	65.33
Fe (mg/l)	0.48	2.02	2.88	2.96	3.34	4.18	4.69
Pb (mg/l)	0.11	0.52	1.68	1.97	2.32	3.16	3.57
Cu (mg/l)	0.06	0.6	0.11	0.16	0.19	0.29	0.37
Cr (mg/l)	0.02	0.05	0.8	0.9	0.11	0.16	0.24
Cd (mg/l)	0.01	0.10	0.15	0.21	0.27	0.40	0.47
Ni (mg/l)	5.27	8.43	13.77	19.96	27.21	32.06	37.48

Key: Co – Control/ soil before irrigation

VEGETATIVE GROWTH PARAMETERS

Height of the maize crop during period of irrigation with varying concentrations of untreated brewery effluent

The height of the maize crops irrigated with different concentration of the effluent for 12-week period is shown in figure 1. The result showed that the height of the maize plant increased during the germination period with increasing concentration of the effluent. The mean height attained by the maize plant at different concentration of the effluent ranged from 50±0.10 to 117±0.10 cm. The plant height significantly ($p<0.05$) increased with increase in effluent concentration to 100%. This can be attributed to the fact that nitrogen promoted vegetative growth in maize as reported by Shah *et al*. (2006).

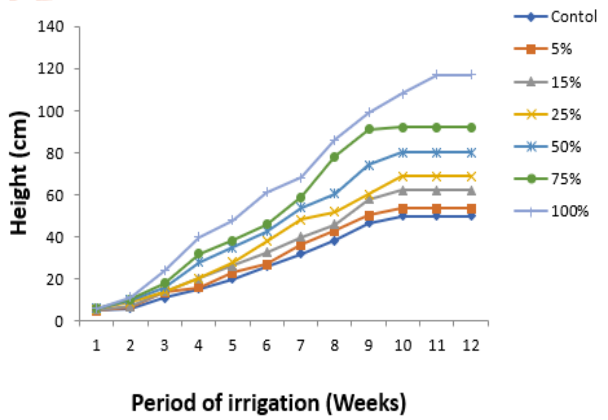

Figure 1: Mean height of maize crops during irrigation with different concentrations of untreated brewery effluent

Number of leaves of the maize crop during 12 weeks irrigation with varying concentrations of untreated brewery effluent

Figures 2 and 3 showed the maize plant and the number of leaves of the maize crops respectively during 12 weeks irrigation with varying concentrations of untreated brewing effluent. The highest number of leaves was observed in the soil treated with 100% concentration of the effluent, while the least number of leaves was observed in soil treated with the control. The number of leaves could also be affected by nitrogen level. There was significant ($p<0.05$) increase in number of leaves as effluent concentration increased. This result is in agreement with the findings of Cox *et al*. (1993) who reported that higher rate of nitrogen promotes leaves development during growth period.

Figure 2: Maize plants at 12 weeks

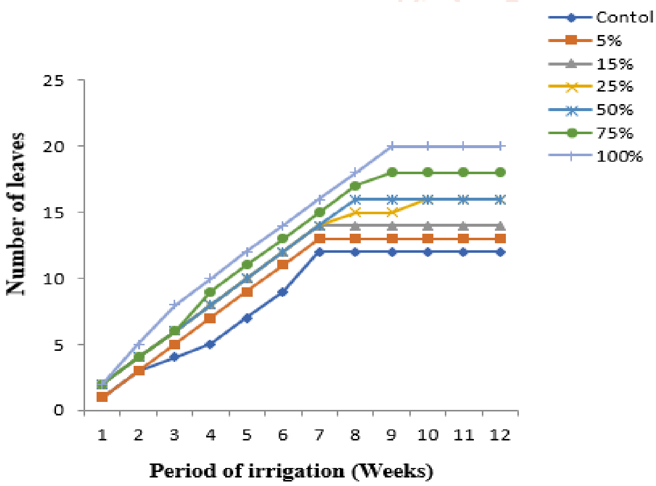

Figure 3: Mean number of leaves of maize crops during irrigation with different concentrations of untreated brewery effluent

Chlorophyll content of the maize leaves at 8th week during irrigation with of varying concentrations of untreated brewery effluent.

Figures 4 and 5 showed the maize plants at 8weeks and the chlorophyll content of the maize leaf respectively planted on the soil irrigated with different effluent concentrations. The chlorophyll content of the leaves in the various setups ranged from 2.28±0.01 to 8.90±0.01. While the highest chlorophyll content was observed in 50% concentration, the least was observed in the control setup. The chlorophyll is one of the important biochemical content which is used as an index of production capacity of the plant. The chlorophyll a, b and total chlorophyll contents increased at 50% concentration of brewery effluent irrigation. It however, decreased as the effluent concentration went above 50%. This may be due to the impact of the concentrations of metals/micronutrients present in the effluent as reported by Sivaraman and Thamizhiniyan (2005). Iron, magnesium, potassium, zinc and copper are basically essential for the synthesis of chlorophyll but at regulated limits (Rao and Kumar, 2007).

Figure 4: Maize plants at 8 weeks

Fresh and dry weights of maize crop after 12weeks of irrigation with varying concentrations of untreated brewery effluent

The maize yield at different concentrations of the effluent irrigation as well as the weights (dry and fresh) per cob of the maize are shown in figure 6 and 7 respectively. The highest fresh and dry weight was observed in maize harvested from soil treated with 50% effluent concentration while the least fresh and dry weights were observed in the control setup.

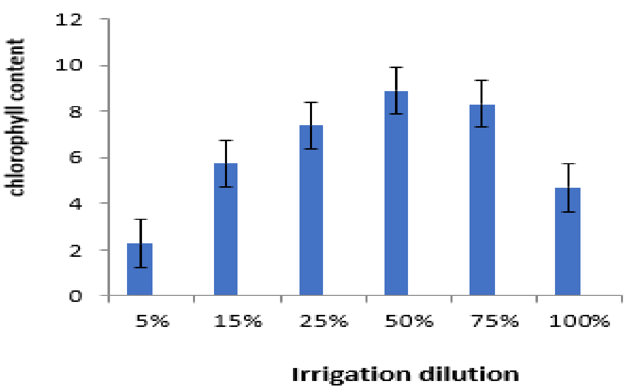

Figure 5: Mean chlorophyll content of the maize leaves at 8th week during irrigation with brewery effluent of varying concentrations.

The weight of the cob increased during irrigation with 50 per cent of brewery effluent concentration. The same trend was observed early in textile effluent on seedling weight of wheat cultivars (Kaushik *et al.,* 2005). The growth promoting effect of the lower concentrations of the effluent was attributed to the decreased concentration of various chemicals present in the effluent (Hari *et al.,* 2000). The reduction in the cob fresh and dry weight at higher concentrations of brewery effluent may also be due to the effect of higher amount of elements present in the effluent which resulted in the reduced yield during effluent irrigation (Kumawat *et al.,* 2001). Application of high rate of phosphorus has been reported to be capable of causing nutrient imbalance and consequent yield reduction of maize (Ayodele and Akinola, 1982). It was also observed that industrial effluents could also delay the time of flowering and fruiting (Uaboi-Egbenni, 2009).

Figure 6: Maize yield at different concentrations of the effluent irrigation.

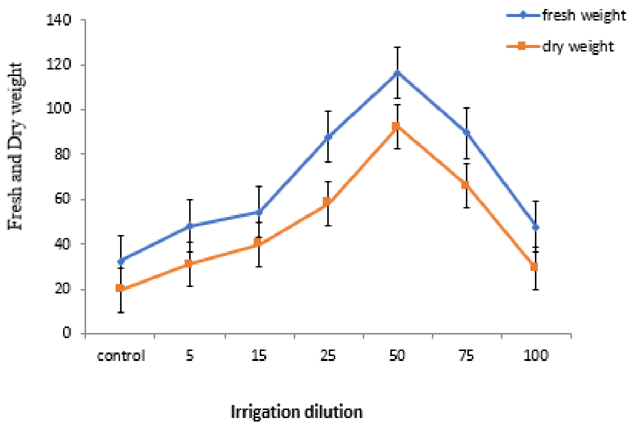

Figure 7: Mean fresh and dry weights of maize crop after 12weeks of irrigation with varying concentrations of untreated brewery effluent.

Number of seeds on the maize cob after 12weeks of irrigation with varying concentrations of untreated brewery effluent

The harvested maize seeds arranged in decreasing order of yield and the number of seeds per maize cob harvested from different concentration of the effluent are shown in figures 8 and 9 respectively. The decreasing order of the number seeds observed in the setups are 50% < 75% < 25% < 15% < 5% < 100% < control.

Figure 8: Harvested maize arranged in decreasing order of yield

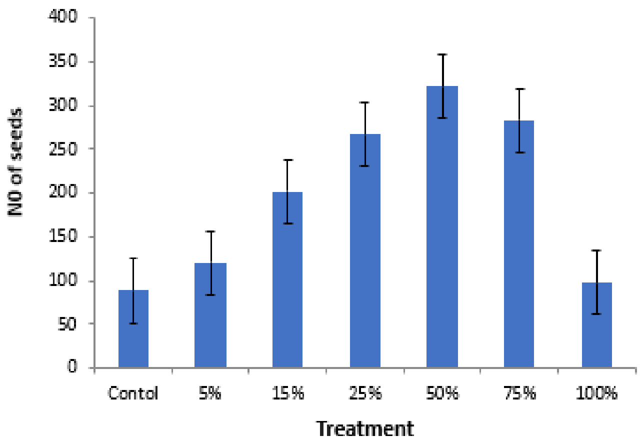

Figure 9: Mean number of seeds on the maize cob after 12weeks of irrigigation with varying concentration of untreated brewery effluent

Root length of the maize plant after 12weeks of irrigation with varying concentration of untreated brewery effluent

The roots of the maize plants as well as the mean length of root of the maize plants after 12weeks of irrigation are presented in figures 10 and 11 respectively. While the longest root length (15±0.115 cm) was observed in the soil treated with 50% effluent, the shortest root length (6.9±0.06 cm) was seen in the control setup.

Figure10: Roots of the maize plant after harvesting

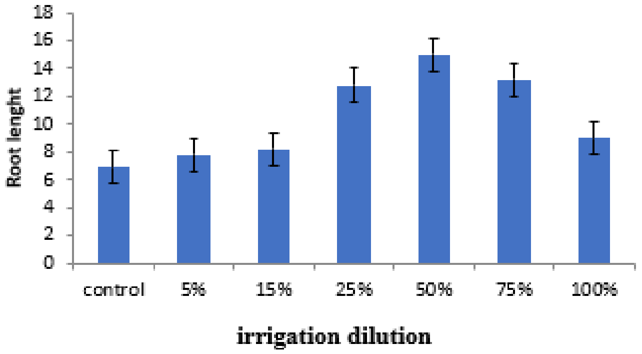

Figure 11: Mean root length of the maize plant after 12weeks of irrigation with varying concentration of untreated brewery effluent

Heavy metals content of the maize seeds harvested after 12weeks of irrigation with varying concentration of the untreated brewery effluent.

Result obtained from the heavy metal analysis of the maize harvested from the soil treated with different concentrations of the effluent are shown in Table 3. The concentrations of Fe, Pb, Cu, Cr, Cd and Ni in the various effluent treatment ranged from 0 – 1.46, 0 – 0.24, 0 – 0.18, 0.1 – 0.15, 0 - 0.16 and 0 – 0.16 respectively. None of heavy metal concentration of the maize crop was above WHO (2006) standard. There were traces of heavy metal in the maize harvested from the soil after the irrigation with the various effluent concentrations. The heavy metals however, were within acceptable limits, and thus the harvested crops are not considered toxic as reported by Mensah *et al*. (2009). Chojknacka (2005) stated that chromium as well as other heavy metals generally move from soil and water to plants.

Table 3: Heavy metals content of the maize seeds harvested after 12weeks of irrigation with varying concentration of the brewery effluent.

Parameter (mg/g)	Treatments							
	Control	5%	15%	25%	50%	75%	100%	FAO/WHO
Fe	0.00	0.34	0.44	0.72	1.04	1.38	1.46	425.5
Pb	0.00	0.04	0.11	0.16	0.19	0.22	0.24	0.3
Cu	0.00	0.00	0.08	0.11	0.12	0.14	0.18	73.3
Cr	0.01	0.01	0.02	0.05	0.08	0.12	0.15	2.3
Cd	0.00	0.07	0.09	0.11	0.12	0.15	0.16	0.2
Ni	0.00	0.00	0.08	0.09	0.11	0.15	0.16	67

CONCLUSION

The physicochemical analysis of Intafact Beverages Ltd effluent was carried out and the result showed most parameters were within WHO standards for irrigation. Results showed that 50% untreated effluent concentration gave higher maize yield and had the highest number of seeds per cob, while 100% effluent gave the highest number of leaves as well as plant height. Different physicochemical properties of the soil were analyzed and found relatively higher in irrigated land with effluent than that of the control. Although the effluent application resulted in high macro and micro nutrients and heavy metal content of the soil, the levels were within acceptable limits and the maize was found to be good for consumption. The study showed that maize can safely be grown with untreated brewery effluent, but it will give a better yield when diluted with water at 1:1 ratio.

REFERENCES

[1] Adelowo, F. and Agele, S. (2016). Spectrophotometric analysis of phosphate concentration in agricultural soil samples and water samples using molybdenum blue method. *Brazilian Journal of Biological Sciences,* 3: 407-412.

[2] Ahaneku, I. E. and Okpara, M. (2010) Performance evaluation of portable sprinkler irrigation system in Ilorin, Nigeria. Indian Journal of Science and Technology, 3(8): 853-857

[3] Aloa, O., Arojojoye, O., Ogunlaja, O. And Fumuyiwa, A. (2010). Impact assessment of brewery effluent on water quality in Majawe, *Ibadan, Southwestern Nigeria. Researcher*, 2(5): 21 – 28.

[4] American Public Health Association (1998). Standard methods for the Examination of Water and Waste water. 20th edition. *American Public Health Association, Washington,* P 1134.

[5] Ayodele, O. and A. Akinola, (1982). An attempt to evaluate phosphorus fertilizer requirements of Western Nigeria savannah soils. *Nutrient Cycling Agroecosystem,* 3: 293-302

[6] Chojnacka, K. A Chojnacki, A. and Gorecka, H. (2005) Bioavailability of heavy metals from polluted soils to plants. Science *of the total Environment* 337 (1-3), 175-182

[7] Cox, W. J., Kalonge, S., Cherney, D. J. R. and Reid, W. S. (1993). Growth yield and quality of forage maize under different nitrogen management practices. *Agronomy Journal*, 85: 341-347.

[8] Driessen, W. and Vereijeken T. (2003). Recent developments in biological Treatment of brewery effluent. Paper presented to the Institute and Guide of brewery convention, Livingstone, Zambia. 165-166.

[9] Egwuonwu C. C., Uzoije A. P., Okafor V. C., Ezeanya N. C. and Nwachukwu M. U. (2012) Evaluation of the Effects of Industrial Wastewater Discharge on Surface Water (A Case study of Nigeria Breweries Plc Enugu) Greener Journal of Physical Sciences, Vol. 2 (3): 056-063.

[10] FAO. (1994). Water Quality for Agriculture. FAO Irrigation and Drainage Paper 29 Rev. 1. Rome: FAO. Pp. 1-10

[11] Hari Om, Katyal, S. K, Dhiman, S. D., (2000) Response of two rice (Oryza sativa) hybrids to graded levels of nitrogen *Indian Journal of Agricultural Sciences,* 70(3): 140-142

[12] Hussain, I. Raschid, L; Hanjra, M. A. and Hoek, W. V. (2001). A framework for analyzing socioeconomic, health and environmental impacts of wastewater use in agriculture in developing countries. *International Water management Institute,* 26: 294-325.

[13] Ibekwe, V. I, Offorbuike, J. O and Nwaiwu, O (2004) Bacteriological and Physico-Chemical Qualities Of Waste Water from a Bottling Company in Owerri, Nigeria. *Global Journal of Environmental Sciences*, Vol. 3(1&2): 51-54

[14] Ike Christian, C., Odika Prince, C, Okorie Peace, E. (2019) Impact of brewery wastewater sludge on Microbiological quality of Agricultural soil. *Journal of Ecobiotechnology*, 11: 13-17

[15] Kamble, P., Mane, R. and Tiwana, A. (2015). Estimation of Chlorophyll Content in Young and Adult Leaves of Some Selected Plants. *Universal journal of environmental research and technology.* 5: 306-310.

[16] Kanagachandran, K. and Jayerantene, R. (2006) Utilisation potential of brewery wastewater sludge as an organic fertilizer, *Journal of the Institute of Brewing,* 112 (2): 92–96.

[17] Kaushik, Priya & Garg, V. K. & Singh, Bhupinder. (2005). Effect of textile effluents on growth performance of wheat cultivars. Bioresource technology. 96. 1189-93.

[18] Kowsalya, N., Karrunakaran, C. M., Deecaraman. M and Vijayalakshmi, M. (2010) Physico-chemical characterisation of brewery effluent and its degradation using native fungus aspergillus nigerr. *Journal of industrial pollution control,* 26 (2): 171-176

[19] Kumawat, D. M., Tuli, K., Singh, P. & Gupta, V. (2001). Effect of dye industry effluent on germination and growth performance of two rabi crops. *Journal of Ecobiology,* 13 (2): 89-95

[20] Kundu, P. K., . Acharjee, T. K and Mojid, M. A. (2013). Growth and yield of wheat under irrigation by sugar mill's wastewater. *Progress in Agriculture,* 24(1and2): 211- 218.

[21] Lenin, M., Thamizhiniyan, P. Sivakumar, P. V. (2009) Sugar Mill Effluent Toxicity in Crop Plants, *Journal of Phytology* 1(2009) 2, 68-74

[22] Mahalingam Lenin, Mariyappan Senthil Kumar and Thamarikannan Ravi Mycin (2014), Effect of Sago Factory Effluent on Seed Germination and Seedling Growth of Gingelly (Sesamum Indicum L.) Varieties). *International Journal of Life Sciences, Biotechnology and pharmaceutical Research,* 3: 151-160.

[23] Mensah, J. K., Okoli, R. I., Turay, A. A. and Efosa, O. (2009). Phytochemical analysis of medicinal plants used for the management of hypertension by Esan people of Edo state, Nigeria. Ethnobotanical Leaflets. 13: 1273-1287

[24] Nagarajan, R., Rajmohan, N., Mahendran, U. and Senthamilkumar, S (2010) Evaluation of groundwater quality and its suitability for drinking and agricultural use in Thanjavur city, Tamil Nadu, India. *Environmental Monitoring and Assessment,* 171(1): 289-308

[25] Navarro, F. and Vincenzo, T. (2019) Waste Mismanagement in Developing Countries: *A*

Review of Global Issues International Journal Environmental Research Public Health, 16(6): 1060.

[26] Ogbu, K. C., Ebenebe, C. I. and Abajue, M. C. (2016) Physico-Chemical Characteristics of Ama Brewery Effluent and its Receiving Ajali River in Udi, Enugu State, Nigeria. *Animal Research International* 13(2): 2392 – 2399

[27] Okoye, N. H., G. E. Obidike, and J. K. C. Nduka. 2011. Analysis of untreated effluents from soap factories in Aba, Abia State, Nigeria. *Journal of Basic Physical Research*, 2(2): 21–25.

[28] Olorode, O. A. and Fagade, O. E. (2012). Comparison between a brewery effluent and its receiving stream in Ibadan based on their physical, chemical and microbiological analysis. *International Journal of Basic and Applied Science,* 1(2): 293 – 299.

[29] Olowookere, F. M, Alatise M. O, Faloye, O. T(2018) Evaluation of wastewater reuse and suitability for agricultural purpose in Akure, Nigeria. *Center for Interdisciplinary Geriaric Research*, Vol. 20, No. 3 61-69

[30] Oshunsanya, S. O. (2018). Relevance of Soil pH to Agriculture. In: Soil pH for Nutrient Availability and Crop Performance, *SuarauOshunsanya, IntechOpen*, Pp 98-104

[31] Rao, G. and Kumar, N. V. (2007). Impact of tannery effluent on seed germinability and chlorophyll *contents of Cicerarientinum L. Poll. Res.,* 2: 33-36.

[32] Rocquigny, P. (2019) Estimating date of grain corn maturity from silking stage. https://manitobacorn.ca/author/pam-de-rocquiny. (accessed august 2021)

[33] Samuel, F. G., Eugene, A. E and Andrew, N., (2014) Microbial Impacts of Brewery Effluent Discharge on Sissa River: A Case Study of Kaase in Kumasi, Ghana. *Research Journal of Microbiology*; 9: 239-245

[34] Senthilraja, K. Jothimani, P and Rajannan, G. (2013). Effect of brewery wastewater on growth and physiological changes in maize, sunflower and sesame crops. International Journal for Life Sciences and Educational Research. 1. 36-42.

[35] Shah, S. T. H., Zamir, M. S. I., Waseem, M., Ali, A., Tahir, M. and Khalid, W. B., (2009). Growth and yield response of maize (Zea mays L.) to organic and inorganic sources of nitrogen. *Journal of Life Social Science,* 7: 108-111.

[36] Sivaraman, M. and Thamizhiniyan, P. (2005). Effect of sago factor effluent on seed germination, growth and chlorophyll content of blackgram (Vigna mungo (L.) Hepper) seedlings. *Journal of Annamalai University PART B Science*, 47-51

[37] Sumathi, A. ; Prasad, V. Babu Rajendra; Vanangamudi, Mallika (2018) Influence of plant growth regulators on yield and yield components in pigeonpea. *An International Journal* Vol. 41 Issue 3, p392-398.

[38] Tai Fagbemi (1996) Maize response to urea and Superphosphate in pot experiment with soils derived from alley Cropping. *Soil and plant science* 46: 1 18-23

[39] Thapa, V. (1994). Effect of Industrial Effluent on Seed Germination and Seedling Growth in Some Cereals. M. Sc. Thesis, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal. Pp 20-31

[40] Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. (2014). Compendium of Sanitation Systems and Technologies – (2nd Revised Edition). Swiss Federal Institute of Aquatic Science and Technology (Eawag), *Duebendorf, Switzerland.* p. 175.

[41] Uaboi-Egbenni P. O., Okolie, P. N., Adejuyitan, O. E., Sobande, A. O. and Akinyemi, O. (2009) Effect of industrial effluents on the growth and anatomical structures of Abelmoschus esculentus (okra) *African Journal of Biotechnology* Vol. 8 (14), pp. 3251-3260,

[42] United Nations Department of Economic and Social Affairs (UNDESA) (2018). "World Urbanization Prospects". Retrieved 26 February 2021. Accessed on 17/2/2022

[43] World Health Organization. (2006). WHO guidelines for the safe use of waste water excreta and greywater (Vol. 1). *World Health Organization.*