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An Insight into the Physical and Chemical Status of Salon Effluent Impacted Soil Seeded With Stubborn Grass

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ABSTRACT: Soil polluted with salon hair effluent was seeded with stubborn grass (*Sida acuta*) and studied for 90 days to determine the physical, chemical and trace metal status. Soil samples were collected twice a month from pristine soil (PS), un-remediated salon effluent polluted soil (EPS) and salon effluent polluted soil seeded with stubborn grass (SGT) and subjected to physical and chemical analysis using standard procedures. Trace metals were analysed using an atomic absorption spectrophotometer. The results showed improved soil pH (weakly alkaline status), low total organic carbon, nitrate, phosphate and sulphate, Fe, Zn, Mn and Cu in SGT compared to EPS. There were no impactful differences in the pH, total organic carbon and nitrate between PS, EPS and SGT at 0.05 probability limits, while the statistical analysis of the trace metal showed the existence of reasonable differences in Fe, Mn and Cu between PS, EPS and SGT at 95% confidence interval. The findings from this study showed that stubborn grass can be used in phytoremediation of salon effluent polluted soil as it improves the physico-chemical and trace metal status of the soil.

Keywords: Salon effluent; Effluent polluted soil; Stubborn grass; Trace metal

Introduction

The Physical and chemical status of soils differs from location to location occasioned by interplays from biotic and abiotic factors (Amupitan, 2023). The activities of man in modern times intentionally or by oversight have led to the presence of foreign substances which in turn tend to define the status of the soil or alter the original soil structure and its physical properties. Elements of nature such as flooding, increase surface run-offs, volcanic eruptions with displaced lava and ash, increases in diurnal temperatures has also impacted the status of any given soil (Ayo, 2001).

Over the years in Nigeria and part of the developing countries of the world, the beauty and cosmetic industries have evolved from natural presentation to enhanced appearance by increased use of chemical enriched products (Amupitan, 2023). This has led to hair beauty salon opening up in virtually every major street and business mall (Tyohemba *et al.*, 2017). In the hair industries, chemical rich formulas abound in shampoos, relaxers, conditioners, dyes and other oily cosmetic products (Tyohemba *et al*., 2017).

Wastes generated from beauty hair salons are not often treated before being discharged into the environment, while others may be discharged via constructed drains into water bodies. Reports from Tyohemba *et al*. (2017), showed that effluent from hair saloon discharges was oily with characteristic polyaromatic compounds.

The chemicals in the effluent can tilt the physical as well as the chemical properties of receiving water bodies or soil. According to Bowers *et al*. (2002), people who work in hairdressing- salons and their clients are exposed to different chemicals present in the shampoos, relaxers and conditioners used in the salon.

Pollution by oil-rich pollutants has been linked to a decrease in soil fertility, an alteration in the soil ecosystem and changes in groundwater (Stephen *et al.,* 2021). Pollution that stems from salon effluent is characterized by colour changes in soil and sometimes odour from standing water bodies (Amupitan, 2023). The diversity of chemicals in the effluent could translate to poison emanating from chemical and biological origin when absorbed by edible plants (Oche *et al.*, 2020). Ajuzie and Osaghae (2011) were of the opinion that salon effluent plays a role in increasing chemical oxygen demand (COD), as well as the biological oxygen components of soil - receiving salon effluent**.** According to Chude and Ekpo (2010), endocrine disorders in fish and wildlife have been linked to surfactants and detergents which are major ingredients of cosmetics.

As the saloon enterprises increase so is the effluent generated. These effluents impacting soil and water bodies cannot be left alone with the attending future health issues it may pose. Hence, there is a need to look for an easy and harmless way- phytoremediation, of mitigating the presence of contaminants which is rich in both trace metals and polyaromatic compounds (Tyohemba *et al*., 2017). Plants and plant products have been reportedly used in reclaiming polluted soil. One such consideration is the seeding of stubborn grass – *Sida acuta*, which is not edible by animals and human beings (Stephen and Ijah, 2017). These plants abound in disturbed soils and are commonly found growing along the street. It has the proven ability to withstand harsh environmental conditions (Stephen, 2014).

Materials and methods

Study area: The study area was Lokoja, Kogi State, Nigeria. According to Stephen (2014), Lokoja is on 144.0 ft above sea level and is situated between latitude 7°48' North and longitude 6°44' Ifatimehin (2007), reported that Lokoja falls within the rich agricultural zone of the Southern Guinea Savannah with an annual rainfall of about 900-1700 mm. The average temperature of the experimental area is 30 °C.

Collection of soil samples: Samples of soil were picked from the vicinity of different hairdressing salons in Ganaja village along Ajaokuta road from a depth of 0-10 cm using a standard soil auger into polyethylene bags and transported to the botanical garden of Salem University Lokoja. The soil samples were merged to form a composite sample and separated into four plastic perforated bowls measuring 47 cm in diameter at the top, 30 cm at the base with a depth of 18 cm. The bowls were flooded daily for seven days with one-litre salon effluent obtained from different hairdressing salons. A non-contaminated soil was also collected from the community which served as control for the experiment, PS. Two of the bowls contained only the added salon effluent and were labelled EPS (effluent polluted soil), while the other two were labelled SGT (effluent polluted soil seeded with stubborn grass). The bowls labelled SGT were seeded with seedlings of stubborn grass one week after simulation with effluent from hairdressing salons. The bowls were exposed to the sun in the botanical garden for 90 days. Sampling of soils for physicochemical and trace metal properties was conducted every two weeks. Samples were collected from each of the labelled bowls (PS, EPS and SGT) and homogenised before carrying out the analysis.

Soil physico-chemical analysis: The pH and moisture contents were determined using the methods described by Kalra and Maynard (1991). The particle size of the soil, total organic carbon, total nitrogen and available phosphorus were determined as described by Onyeonwu (2000), while trace metals were analysed using an atomic absorption spectrometer (AAS PG 550 model, England) using their specific lamps as described by Adelekan and Abegunde (2011).

Statistical analysis: Statistical Package for Social Sciences version 19 (IBM SPSS) was employed to analyse the data collated using analysis of variance.

Results and Discussion

Preliminary analysis of pristine soil (PS) in this study is shown in Table 1. It has a pH of 5.57, 78 % sand, 3 % silt and 12 % clay. The moisture content was 6.12 %, with total carbon at 4.96 % and total nitrogen at 0.53 %. The PS analysis indicated a sandy soil low in moisture, total carbon, total nitrogen and slightly acidic pH. Sandy soil is associated with poor nutrients, particularly nitrogen. This stemmed from the absence or low level of organic matter (Ayo, 2001).

Table 1: Physicochemical parameters of pristine soil

Parameters	Values
Clay (%)	3
Silt (%)	8
Sand (%)	69
Texture	Sandy soil
pH	5.57
Moisture (%)	6.12
Total carbon (%)	4.96
Total Nitrogen (%)	0.53

Table 2 shows the physico-chemical and trace metal properties of the salon-effluent. The pH of the soil was weakly acidic. Total carbon and nitrates were low in the salon effluent, while the phosphate and sulphates were high. These values were not consistent with the values obtained by Albert and Tanee (2016). They reported lower total carbon (1.1 %), phosphate (0.1%) and pH of 6.8 in salon effluent use in irrigation of *Zea mays* and *Vigna unguiculata*. The pattern of trace metals in the salon effluent was Zn>Fe>Ni>Mn>Pb.

Table 2: Physicochemical and trace metal qualities of Salon effluent

Parameters	Values
pH	6.40
EC (uS/cm)	1.76
Total carbon (%)	2.40
Nitrate (%)	0.46
Phosphate (%)	8.11
Sulphate (%)	6.07
Fe (ppm)	4.13
Zn (ppm)	4.32
Mn (ppm)	1.30
Ni (ppm)	10.9
Pb (ppm)	0.67

Table 3 shows the physico-chemical properties of the pristine soil (PS), salon-effluent polluted soil (EPS) and salon effluent polluted soil seeded with stubborn grass (SGT). The pH ranged from 5.20±3.96 – 7.46±0.18. The EPS was more acidic compared to SGT and PS. There was no reasonable difference at 5% probability levels in the pH of the PS, EPS and SGT. The pH of PS, EPS and SGT observed in this study was weakly acidic and fell within the acceptable range of 6 - 9 by the World Health Organization, WHO (2004). Nkansah *et al*. (2016) and Tyohembe *et al*. (2017) reported similar pH values for salon effluent in waste water.

The pH observed in stubborn grass seeded soil was weakly alkaline (7.46 ± 0.18). This is an indication of plant root-microbial interaction leading to improved soil pH. These pH values will enhance the phytoremediation of organic pollutants (Stephen and Temola, 2014) and the growth of plants (Albert and Tanee, 2016).

The electrical conductivity was higher in the salon effluent polluted-soil seeded with stubborn grass (SGT) followed by effluent polluted-soil without stubborn weed (EPS) and the control soil. There were reasonable differences in the electrical conductivity values in PS, EPS and SGT at 0.05 probability level. The electrical conductivity in this study was lower than 400 µS/cm in PS, EPS and EPS. This indicates that the salon effluent may not impact plants and microbes' activities in the soil. Stephen (2014) was of the opinion that electrical conductivity less than 40 µS/cm will favour functions of plants and microbes in their synergy to metabolise organic pollutants from the soil.

The total carbon concentration ranged from 0.77±0.03 to 12.60±19.00 %. Effluent polluted-soil (EPS) had the highest concentration of total carbon during the study. There was no reasonable difference in the total carbon concentrations in the PS, EPS and SGT at a 95 % confidence interval. The enhanced values of total carbon observed in effluent polluted soil (EPS) compared to pristine soil (PS) may be due to the presence of salon effluent in the soil (Kayode *et al*., 2009). The carbon concentration in stubborn grass-seeded soil was lesser than the effluent-polluted soil due to the absorption and utilization of the carbon as part of the nutrients for growth by the stubborn grass. However, this range of values in this study may be beneficial to autotrophic organisms in the soil.

The nitrate concentration was low in the PS, EPS and SGT. It ranged from 0.39±0.40 - 0.62±0.25 %. The maximum nitrate concentration was observed in effluent-polluted soil followed by hair salon effluent soil seeded with stubborn grass. There was no impactful difference (p >0.05) in the nitrate levels of PS, EPS and SGT (Table 3). Studies have shown that salon effluent is low in nitrate (Albert and Tanee, 2016, Tyohembe *et* *al*., 2017). Nitrate concentration was lower in SGT compared to PS and EPS. This implies that plants (stubborn grass) and microbes can easily utilize nitrates for their metabolic activities. This is in consonant with the reports of Ajuzie and Osaghae (2011) that holds the view that nitrates are needed significantly for microbial metabolism and healthy plant growth.

Table 3: Physicochemical qualities of salon effluent polluted soil (M+SE) seeded with stubborn grass

Parameter	**PS**	**EPS**	**SGT**
pH	$6.87{\pm}0.22^{a}$	$5.20{\pm}\ 3.96^{a}$	7.46 ± 0.18^{a}
EC (µS/cm)	$0.63{\pm}0.02^{c}$	$1.22{\pm}0.07^{b}$	$1.47{\pm}\ 0.03^{a}$
Total carbon (%)	$0.77{\pm}0.70^{a}$	$12.60{\pm}19.00^{a}$	$10.26{\pm}\ 0.18^{a}$
Nitrate (%)	$0.39{\pm}0.40^{a}$	$0.62{\pm}0.25^{a}$	$0.42{\pm}\ 0.01^{a}$
Phosphate (mg/kg)	$1.81{\pm}1.41^{a}$	$15.23{\pm}15.80^{b}$	$12.47{\pm}\ 3.96^{a}$
Sulphate (mg/kg)	$0.63\ {\pm}0.11^{b}$	$1.80{\pm}\ 0.96^{a}$	2.90 ± 3.72^{a}

a,b and c: means represented by different superscripts along the same row are reasonably ($p<0.05$) different.
PS: Pristine soil, EPS: Effluent polluted soil, SGT: Stubborn weed + effluent polluted soil. Results are a mean of six replicates.

The phosphate concentration ranged from 1.81 ± 1.41 – 15.23 ± 15.80 mg/kg. The pattern of phosphate concentration showed a drastic increase from PS to SGT and EPS. Statistically, there were reasonable differences ($p<0.05$) in the level of phosphate found in PS, EPS and SGT at 0.05 probability limits. The pattern of phosphate concentration is similar to that of nitrate concentration. EPS had the highest concentration of phosphate closely followed by SGT. This may be due to phosphate compounds in the salon effluent used in simulating the soil. However, the reduced concentration of phosphate in the SGT may be ascribed to uptake by stubborn grass for growth. Phosphate like nitrates plays an important role in microbial growth (Albert and Tanee, 2016), as well as plant-aided degradation of oil-rich soil (Ajuzie and Osaghae, 2011).
The sulphate level was higher in the salon effluent-polluted soil compared to the effluent- polluted soil treated with stubborn grass and pristine soil. It ranged from 0.63 ± 0.11 to 2.90 ± 3.72 mg/kg. There were reasonable differences in the sulphate concentrations found in PS, EPS and SGT at 0.05 probability limits. The sulphate level was higher in the salon effluent-polluted soil compared to the effluent-polluted soil seeded with stubborn grass and pristine soil. This implies that sulphate-rich EPS may become acidic when water accumulates in the environment (Janik *et al*., 2018). SGT soil had lower sulphate concentration compared to EPS. This is an indication that phytoremediation using stubborn grass may ease or reduce sulphate from accumulating in the soil and eventually play a role in improving soil pH.
Table 4 shows the trace metal concentrations of the pristine soil (PS), salon effluent polluted soil (EPS) and salon effluent polluted seeded with stubborn grass (SGT). Iron (Fe) ranged from 2.29 ± 0.01 to 6.83± 0.06 mg/kg. The highest concentration of Fe was observed in salon effluent polluted soil (EPS), followed by PS and SGT. Reasonable differences were observed in the concentration of iron in PS, EPS and SGT at 0.05 probability limits. The lower concentration observed in SGT soil undergoing phytoremediation may be adduce to accessibility and bioaccumulation of Fe by stubborn grass (Stephen and Ijah, 2017).

Table 4: Trace metal concentration of pristine soil, salon effluent and effluent polluted soil (M+SE mg/kg)

Parameter	**PS**	**EPS**	**SGT**
Fe	$2.29{\pm}0.01^{c}$	$6.83{\pm}\ 0.06^{b}$	$1.59{\pm}\ 0.46^{a}$
Zn	$0.65{\pm}0.030^{b}$	$3.69{\pm}0.04^{b}$	$1.95{\pm}\ 0.53^{a}$
Mn	$0.40\ {\pm}0.01^{a}$	$1.64\ {\pm}0.09^{b}$	$0.89{\pm}\ 0.06^{a}$
Cu	$0.11\ {\pm}0.01^{b}$	$2.04\ {\pm}0.20^{c}$	0.04 ± 0.00^{a}
Ni	$0.24{\pm}0.02^{a}$	$0.68{\pm}0.03^{a}$	$0.89{\pm}\ 0.28^{a}$

a,b and c: means represented by different superscripts along the same row are reasonably ($p<0.05$) different.
PS: Pristine soil, EPS: Effluent polluted soil, SGT: Stubborn weed + effluent polluted soil. Results are a mean of six replicates.
The concentration of Zn in PS, EPS and SGT were lower when compared to the concentration of Fe. The concentration of Zn ranged from 0.65 ±0.03 in PS to 3.69 ±0.04 mg/kg in EPS. There were no reasonable differences ($p>0.05$) in the concentration of Zn in PS, EPS and SGT at 5% probability limits (Table 4).
The trend of Fe uptake in SGT soil undergoing plant treatment was also observed in the uptake of Zn from the soil. This was the perspective explained by Stephen (2014). The author believed that Fe and Zn were easily absorbed by the roots of plants.
The level of concentration of Mn was low in PS compared to EPS and SGT. It ranged from 0.40 ± 0.01 to 1.64 ± 0.07 mg/kg. The highest concentration of Mn was observed in EPS >SGT>PS. A similar pattern was observed in Fe and Zn concentrations in PS, EPS and SGT. There were reasonable differences ($p>0.05$) in the

concentration of Mn present in PS, EPS and SGT at a 95% confidence interval. This shows that growing stubborn grass on salon effluent polluted soil is capable of reducing Mn concentration in the impacted soil. This aligned with the findings of Susarla *et al*. (2002). They postulated that metal concentrations in soil tend to decrease in the presence of plants.

The concentration of Cu ranged from 0.100 ± 0.93 to 2.04 ± 0.20 mg/kg. There were reasonable differences ($p<0.05$) in the concentration of Cu in PS, EPS and SGT at a 95% confidence interval. The levels of Cu were lower than Fe, Zn and Mn in PS, EPS and SGT in this study. Previous studies by Susarla *et al*. (2002), Tanee and Kinako (2008) and Stephen and Ijah (2017) are in agreement that Cu accumulates more than Pb and Mn in plants. This may account for the low concentration of Cu in SGT soil in this study.

A higher concentration of Ni was observed in the salon effluent polluted soil, EPS compared to effluent polluted soil undergoing phytoremediation with stubborn grass (SGT) and pristine soil (PS). The concentration of Ni ranged from 0.24±0.02 – 1.09±0.51 mg/kg. There were no reasonable differences ($p<0.05$) in the concentration of Ni in PS, EPS and SGT at 0.05 probability level (Table 4). Tyohemba *et al.* (2017) reported higher values of Ni in untreated salon effluent wastes in Makurdi. The finding in this study contradicts the report of Tyohemba *et al.* (2017) especially the observation of Ni concentration in EPS. Ayolagha and Nleremchi (2000) observed high concentrations of trace metals in untreated polluted soil. The trace metals such as Zn, Cu and Ni that accumulate from hairdressing salon effluent polluted soil were above acceptable limits of the Federal Environmental Protection Agency, FEPA (1991).

Conclusion

The findings from this research indicate that salon effluent tilts the physicochemical properties of the soil. However, soil undergoing phytoremediation with stubborn grass had better physical and chemical properties compared to the salon effluent-polluted soil. The levels of trace metals in the stubborn grass-seeded soil apart from Ni had lower concentrations compared to untreated salon effluent polluted soil. This is an indication that stubborn grass will be useful in phytoremediation of salon effluent polluted soil.

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