ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 6 No. 1 March 2020*

Impact Assessment of Dyeing Processing Activity on Soils of Selected Sites in Kano Metropolis, Nigeria

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Abstract
Soil quality has been reported to deteriorate due to indiscriminate discharge of untreated textile dye wastewater into the environment. This study aimed at assessing the level of contamination of soils collected from Kofar Mata, Kofar Na'isa and Zawaciki dyeing sites. This was achieved through determining the concentration of soil physicochemical parameters and selected heavy metals. The result showed pH (9.80, 8.30 and 7.80 respectively, which differ statistically at p≤0.05) and electrical conductivity (1129.75µS/cm, 10405.43µS/cm and 13065.22µS/cm respectively, where, Zawaciki had statistical difference with Kofar Mata and Kofar Na'isa at p≤0.05) to have exceeded normal range, signifying soil contamination. All other parameters measured were within normal range for most soils but, their varied concentration made the soils less productive and sustainable. Sodium (143.60Cmol/kg, 155.67Cmol/kg and 120.40Cmol/kg respectively) and potassium (231.01mg/kg, 151.30mg/kg and 140.00mg/kg respectively) relatively had higher concentrations in all the sites, with lead (0.96mg/kg, 0.88mg/kg and 0.87mg/kg respectively) having the least. Also, potassium and chromium were the only elements that had statistical difference within the sites at p≤0.05. This calls for further research on eco-friendly treatment of the dye wastewater before discharging onto soils to prevent further damages.

Keywords: Heavy metals, Physicochemical parameters, Soil quality, and Textile dyes.

INTRODUCTION
Our environment – the earth is a topical issue worldwide because of the serious effect of human actions and activities on it. It provides the source of sustenance for all living organisms including plants, animals and microorganisms and at the same time, it protects, ensures circulation of molecules, substances, compounds, energy and other materials that make the world or earth conducive for living (Miller, 1995). However, human actions and activities such as dyeing have created several environmental problems with varying magnitude from one place to another.

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Dyeing is normally done in a special solution containing dyes and particular chemical material. After dyeing, dye molecules have uncut chemical bond with fiber molecules, and about 10-20% of the dye remains in the dye bath which is discharged along with other residual chemicals as exhausted dye wastewater (Sajjala *et al.*, 2008). The exhausted dye wastewater contains significant quantities of colouring matter which imparts colour to the receiving water bodies and subsequently sinks down to the soil. In addition to imparting colour, dye wastewater also contributes to organic and inorganic load of the receiving soils. Dye wastewaters are typically characterized by residual colour, alkaline pH, excess TDS content, high COD with relatively low BOD values (Sajjala *et al*., 2008).

A new re-dyeing practice has emerged in urban Kano, spreading at a very high speed, with about 30 outfits of these re-dyeing activities in Kano Municipal alone. The increasing spread of this secondary dyeing processing activity is causing some concern to the population. It has become very common to see places where this re-dyeing of textile materials (clothes) is taking place. The interest to change the colour of one's textile material to another seems personal, because people generally have different colour preferences. Similarly, the impact of the discharged of these dyes from this activity on land (soil), aquatic flora and fauna (species, composition, distribution and diversity), public health and environmental safety at present and in the immediate future is not given due consideration (Sani, 2015).

The chemicals used are mainly imported with brand names like blue, yellow, red, etc. These compounds are mixed in various concentrations as solutions to produce specific colour. The containers of these chemicals do not provide any information about the specific preparation, content and concentration, and the practitioners are generally literate (Sani, 2015).

The wastewater from the dyeing process which contains various organic and inorganic contaminants is usually discharged on open land or soil nearby or into drains that subsequently flow to ditches, burrow pits, ponds and other important aquatic ecosystems, thus, making receiving soils poor in physicochemical properties, susceptible to erosion, loss of productivity, sustainability and lowers food chain quality (Ahmad *et al*., 2012).

The soil being a heterogeneous part of the earth stores vital resources that support the survival of living organisms (Ahmad *et al*., 2012), thus, discharge of such dye-containing wastewater makes it undesirable, as a result of the colour and presence of toxic products (generated due to chemical reaction of the dyes) that maybe carcinogenic or mutagenic to life forms (Zaharia *et al*., 2009). Also, excess salts used in the dyeing process, to increase fixation of reactive dyes to fibers, as well as heavy metal components of some dyes may adversely affect both soil and aquatic biota (Law, 1995). Without adequate treatment these dyes can remain in the environment for a long period of time, thus, destroying the soil productivity (Nupur *et al*., 2012).

In many places like Kano, the dye wastewater are not treated or re-processed to remove the harmful or toxic substances before being discharged into the environment. The parts of the environment that subsequently receive this wastewater are the land (soils) and aquatic systems such as lakes, rivers, ponds and streams, resulting in severe contamination in the environment (Sani, 2015). The research was aimed at assessing the level of soil contamination as a result of re-dyeing activities in urban Kano.

MATERIALS AND METHODS

Study Area

Urban area of Kano is located at the central western part of Kano State between latitude 11°59´59.57° – 12°02´39.57°N of the equator and between longitudes 8°33´19.69° – 8°31´59.69°E. It lies in the northern central boundary of Nigeria and is located some 840km away from the edge of the Sahara desert and 1,140km from the Atlantic Ocean. The Kano urban area covers 137 km² (Oseiki, 2009).

A survey of the sites where this activity takes place was conducted using a GPS device (Garmin model 12, USA) and the geographical co-ordinates were transferred onto a digital map of Kano to produce a map showing the specific selected sites of these dyeing processes (Figure 1).
The sampling sites include Kofar Mata, Kofar Na'isa and Zawaciki dyeing pits.

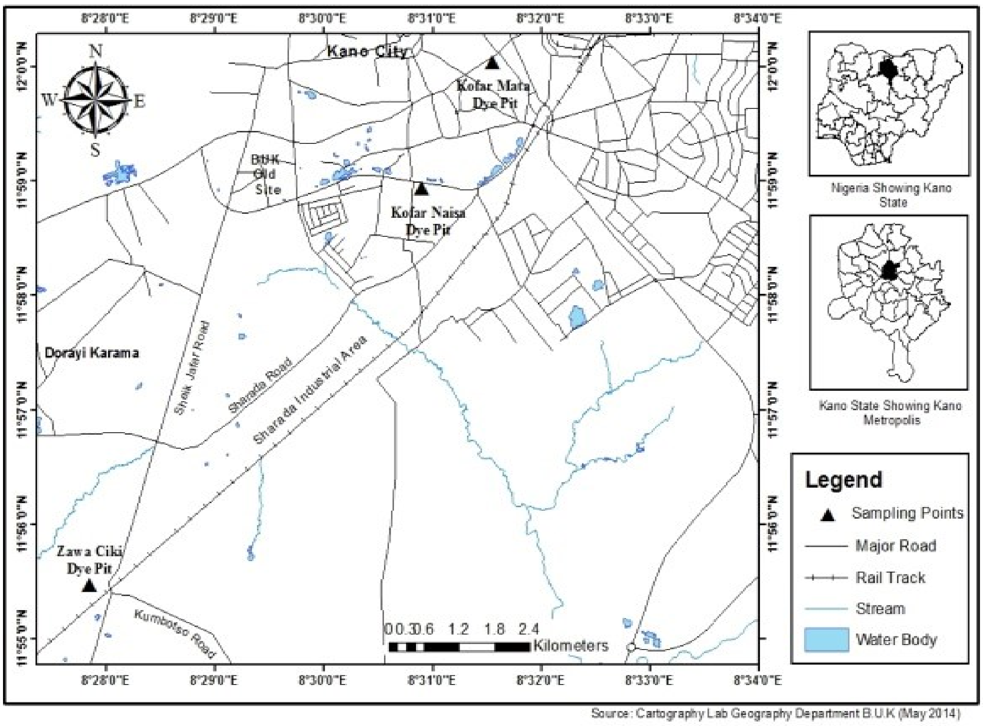

Figure 1: Map of Kano State Showing the Selected Dyeing Activity Sites.

Soil Physicochemical and Heavy Metals Analysis

A soil auger was used to collect the soil samples (10cm depth) at the dyeing sites; these were subsequently transferred into sterilized containers for conveyance to the Department of Soil Science laboratory, Bayero University, Kano. Most of the analyses in this research were carried out *ex-situ* to avoid biological and chemical changes (Ademoroti, 1996).

Soil samples collected from sampling sites were analyzed for various physicochemical parameters such as pH, organic matter, electrical conductivity, sulphate, nitrate and phosphate. Some selected elements including; sodium (Na), magnesium (Mg), potassium (K), zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), calcium (Ca), chromium (Cr) and lead (Pb) were also determined.

The pH of the soil samples were determined at a soil/water ratio of 1:2 (w/v) using HANNA pH meter HI 98129 model. Before use, the pH meter was calibrated with standard buffer of pH solution 7 (Hanna Instruments, 2004; Chimuka *et al*., 2005). Electric Conductivity was obtained using the method of (Bamgbose *et al*., 2000). Determination of organic carbon (OC) was done using the method of Walkley and Black (1934) adopted by IITA (1979). Soil sulphate was determined according to the method of Fox *et al*., (1964). Nitrates and Phosphates were determined using multi-spectrophotometer (at wavelengths 500nm and 890nm respectively) as described by Njosi (2005).

Soil samples were digested according to Sharidah (1999), to determine the concentrations of the elements (i.e. Na, Mg, K, Pb, Zn, Fe, Mn, Cr, Ca, and Cu) using AAS VGP model 210 instrument which was set up at wavelengths specific to each element to be analyzed.

RESULTS

Table 1: Mean Values for Physico-chemical Parameters in Dye-contaminated Soil Samples from Dyeing Activity in Kano Metropolis.

Parameters \ Sites	Kofar Mata	Kofar Na'isa	Zawaciki	Standard
pH	9.80 ± 0.00	8.30 ± 0.00	7.80 ± 0.00	5.50-7.50
Organic Matter (%)	4.82 ± 0.49	1.64 ± 0.35	2.70 ± 0.69	2.00-6.00
Electrical Conductivity (μS/cm)	1129.75 ± 135.07	10405.43 ± 268.23	13065.22 ± 30.12	110.00-570.00
Sulphate (mg/kg)	3.36 ± 1.09	2.05 ± 0.71	2.84 ± 0.49	<3000
Nitrate (mg.kg)	0.81 ± 0.17	1.30 ± 0.28	1.66 ± 0.29	5.00-10.00
Phosphate (mg/kg)	1.98 ± 0.34	4.40 ± 1.10	11.17 ± 1.09	30.00-50.00

The table above shows all the determined parameters with the exception of pH and electrical conductivity (EC) to be relatively within standard limit. Also, electrical conductivity is having the highest values and nitrate having the least values within the sites.

Table 2: Mean Values for Various Elements Determined from Dye-contaminated Soil Samples from Activity Sites, in Kano Metropolis.

Nutrients \ Sites	Kofar Mata	Kofar Na'isa	Zawaciki	Standard
Sodium (Cmol/kg)	143.60 ± 19.51	155.67 ± 7.57	120.40 ± 12.32	200.00
Magnesium (Cmol/kg)	51.23 ± 16.81	10.88 ± 1.00	9.31 ± 1.30	180.00
Potassium (mg/kg)	231.01 ± 0.00	151.30 ± 0.00	140.00 ± 0.00	250.00
Zinc (mg/kg)	13.99 ± 2.60	15.23 ± 3.07	10.46 ± 1.29	300.00
Copper (mg/kg)	13.14 ± 2.01	20.14 ± 3.13	17.39 ± 1.16	140.00
Iron (mg/kg)	3.07 ± 0.33	24.64 ± 3.24	20.57 ± 3.44	25000.00
Manganese (mg/kg)	1.92 ± 0.80	1.31 ± 0.38	1.35 ± 0.35	5000.00
Calcium (Cmol/kg)	4.81 ± 0.53	2.83 ± 0.96	3.64 ± 0.36	2000.00
Chromium (mg/kg)	1.11 ± 0.00	$3.70 \pm 5.44E^{-16}$	$6.67 \pm 1.09E^{-15}$	49.00
Lead (mg/kg)	0.96 ± 0.00	0.88 ± 0.00	0.87 ± 0.00	300.00

The table above shows all the determined elements from the dye-contaminated soil samples to be relatively within the normal range. Potassium and chromium relatively had high concentrations in all the sites compared to other elements, with lead having the least.

DISCUSSION

The results of the physico-chemical analysis of dye contaminated soil samples collected from the three dyeing sites (Kofar Mata, Kofar Na'isa and Zawaciki) is presented in Table 1. The mean pH values for the three soil samples were 9.80, 8.30 and 7.80 respectively, alkaline due to introduction of various soluble salts (Akpoveta *et al.*, 2010). There was statistical difference within the pH values of sites at $p \leq 0.05$. Mean values for Organic matter were 4.82%, 1.64% and 2.70% (statistically different within the sites at $p \leq 0.05$), which is very low for the support of plants and survival of soil organisms. Judy (2016) reported that organic matter concentration higher than 8.00% leads to excessive nutrient availability and other problems such as high pH, high soluble salts etc. Also, soils with organic matter less than 3.00% are said to be less productive. All the three soil samples (Kofar Mata, Kofar Na'isa and Zawaciki) collected had very high electrical conductivity with mean values: 1129.75µS/cm, 10405.43µS/cm and 13065.22µS/cm respectively (with Zawaciki value statistically differing from Kofar Mata and Kofar Na'isa values at $p \leq 0.05$). This may be due to the presence of different ionic compounds as a result of chemical reactions occurring between the dyes, their associates and other substances in the soil (Suteu *et al.*, 2009). Sulphate, nitrate and phosphate had mean values of (3.36mg/kg, 2.05mg/kg and 2.84mg/kg), (0.81mg/kg, 1.30mg/kg and 1.66mg/kg) and (1.98mg/kg, 4.40mg/kg and 11.17mg/kg) respectively and all the three compounds had no significant difference within the sites at $p \leq 0.05$. This may be as a result of sedimentation of compounds from the discharged dye wastewater and effluents from other industrial and domestic activities (Sani, 2015). These substances (sulphate, nitrate and phosphate) in excess have been reported to contaminate both surface and underground water through percolation (Judy, 2016).

The results for the analysis of some selected soil elements from dye wastewater samples collected from the three dyeing sites (Kofar Mata, Kofar Na'isa and Zawaciki) is presented in Table 2. The mean values for sodium were 143.60Cmol/kg, 155.67Cmol/kg and 120.40Cmol/kg. Magnesium had mean values of 51.23Cmol/kg, 10.88Cmol/kg and 9.31Cmol/kg respectively. Calcium had mean values of 4.81Cmol/kg, 2.83Cmol/kg and 3.64Cmol/kg. This may be due to the presence of these substances in the dyes and their associates (Sani, 2015). Judy(2016) reported that pH levels above 7.0 in soils are usually associated with high concentrations of substances like sodium, calcium and magnesium. Mean values for Potassium were 231.01mg/kg, 151.30mg/kg and 140.00mg/kg. A high level of potassium in soil leads to an imbalance of base saturation levels as well as high soluble salts. The mean values for Zinc were 13.99mg/kg, 15.23mg/kg and 10.46mg/kg. Copper had mean values of 13.14mg/kg, 20.14mg/kg and 17.39mg/kg respectively. Mean values for Iron were 3.07mg/kg, 24.64mg/kg and 20.57mg/kg. Manganese had mean values of 1.92mg/kg, 1.31mg/kg and 1.35mg/kg. Chromium had mean values of 1.11mg.kg, 3.70mg/kg and 6.67mg/kg. The mean values for lead were 0.96mg/kg, 0.88mg/kg and 0.87mg/kg respectively. Statistically, only potassium and chromium differ significantly within the sites, all other elements had no significant difference within the sites at $p \leq 0.05$. Also, all the above mentioned elements were found to be within standard limits set by FAO (1972) for waste discharge. The FAO values, are as follows; Na=200Cmol/kg, Mg=180Cmol/kg, Ca=2000Cmol/kg, K=250mg/kg, Zn=300mg/kg, Cu=140mg/kg, Fe=25000mg/kg, Mn=5000mg/kg, Cr=49mg/kg and Pb=300mg/kg. Excessive nutrients in soil can cause adverse effects on plant growth, increase the potential for environmental contamination due to leaching (Judy, 2016).

Chhonkar *et al*. (2000) reported that soils receiving untreated dye wastewater have excessive levels of plant nutrients such as sodium, calcium and potassium as well as other micronutrients and heavy metals. Saleem *et al*. (2011) also reported that excess nutrients (organic and inorganic substances) lead to complex interactions with natural binders in soils causing delay in the normal hydration reaction and release of heavy metals in ground water. In addition, such soils have increased levels of pH, sodicity and electric conductivity.

CONCLUSION

In conclusion, the result of the study indicated that the dye processing activity in urban area of Kano has contaminated the soil of the study areas, which contained high levels of heavy metals and other elements, most of which have exceeded the recommended limits. Some of these compounds have been proven to deteriorate soil quality and fertility, injurious to plant growth, thus, posing serious damage to the environment through ecological interaction.

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