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ORIGINALRESEARCH

EFFLUENTS COMPOSITION: A FUNCTION OF INDUSTRYTYPESINSOUTHWESTERNNIGERIA

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Abstract:
Introduction: The rapid growth ofindustry types has resulted inincreased discharge of effluentsintowater bodies.

Aim: The study aimed atestablishingapatternineffluent loadaccordingtoindustrytypesinLagosmetropolis.

MaterialsandMethods: Theindustrytypesstudiedwerepharmaceuticals, textiles, paints, foods and beverages, basic metals, andconglomerates. Effluent samples were collected bimonthly over a periodof 20 months. Total Dissolved Solids (TDS), pH, alkalinity, total hardness,sulphate,phosphate,nitrate,DissolvedOxygen(DO),BiochemicalOxygen Demand (BOD), Chemical Oxygen Demand (COD) and heavymetalsweredeterminedintheeffluentsaccordingtoAPHAmethods.

Results: Physicochemical characteristics (mg/L) of effluents from textileand pharmaceutical industries were 1160±890 and 630±260 for TDS,316±280 and 230±97 for alkalinity, 60±32.and 53±44 for total hardness,156±73and34±36forsulphate, 1.0±0.3and0.7±0.6for phosphate,60.0±40.0and75±45fornitrate,1.8±1.7and1.3±1.2forDO, 209±72and150±96forBOD,343±130and245±140forCOD,0.7±0.3 and0.5±0.2forZn,1.5±1.0and0.3±1.1forCu,2.5±0.3,0.03±0.03forCr andcorrespondingpHwas10.6±1.1and5.5±1.2respectively.Effluentsfromotherindustrytypes hadlowerlevelsofTDS,alkalinity,phosphate.

Conclusion: Theresultsshowedtextileandpharmaceuticalindustrieshavinghigher pollutionloadinpH,BODandCOD.
Keywords:IndustrialEffluent;Industrytypes;Textile;Pharmaceutical;HeavyMetals;Lagos.

Allco-authorsagreedtohavetheirnameslistedasauthors.

1. INTRODUCTION

Theincreaseinindustrialactivitieshasresultedtoenvironmentalpollutionwhichisoneofthemostsignificantproblemsofthemillenniums.Pollutionofwater, air, and soil is strictly related to human activitiessuch as industry, agriculture, burning of fossil fuels,miningandmetallurgicalprocessesandtheirwastedisposal[1].Industriesthatusesignificantlargeamount of water in their processes include chemicalmanufacturers,textile,pharmaceutical,steelplants,metal processors etc. It is noteworthy that the effluentsand most of by products from these industries create aseriouspollutiontothewaterbodiesandsoilbodies[2].

Partially or untreated industrial effluents may containhigh levels of pollutants which released tothe waterbody systems cause increase in Biochemical OxygenDemand(BOD),ChemicalOxygenDemand(COD),Total Dissolved Solids , Total Suspended Solids , toxicmetals such as Cd, Cr, Ni and Pb,and feacal coliform,and hence make such water unsuitable for drinking,irrigation,andaquaticlifesupport.IndustrialwastewatersimpactincludehighBODfrombiodegradablewastessuchasthosefromhumansewage, pulp and paper industries, slaughter houses,tanneriesandchemicalindustry[3,4].Theeffluent contains various inorganic and organic substances indifferent concentrations which may affect the growthandgerminationofcropplants.Recently,ithasbecomeclearthatpharmaceuticalsreleasedintoenvironment are an important group of environmentalpollutants [5]. Pharmaceuticals are of environmentalconcernowingtotheirspecificbiologicaleffectsnotonlytothetarget patients,butalsoonthegeneralaquaticbiota.Relativetotheirlowbiodegradability,they accumulate to detectable levels and in biologicallyactiveamounts [6].Textile industry wastewaters are oneof the principal sources of pollution in the world. Inparticular, thereleaseofcolouredeffluentsintotheenvironmentisundesirable,notonlyduetotheircolour, but also because many synthetic dyes and theirbreakdown products are toxic and mutagenic [7, 8].Dyes are usually the first contaminant recognized inindustrialtextilewastewater[9].Effluentsfromfoodandbeveragesindustriescontributedsignificantpollutionload[10].Theidentifiedpollutantsintheeffluentswereorganicload,suspendedsolids,phosphate,nitrateandchloridewhichledtoitssignificantpollution.
The increasing demand on water arising from the fastgrowth of industries has put pressure on the limitedwater resources. While most people in urban cities ofthe developing countries have access to piped water,several others still rely on borehole and river water fordomestic use. Most of the rivers in the urban areas ofthe developing world are the endpoints of effluentsdischarged from the industries. Industrial effluents, ifnot treatedandproperly controlledcanalsopollutegroundwater[11].Therefore,boreholesandriversgenerallyhavepoorqualitywaterinaffectedareas. Sincepeopleuseuntreatedwatersfromthesesources, the result is continuous outbreaks of diseasessuchascholera,bilharzia,diarrhoeaandothers[12].

Lagos is the most populated city in Nigeria and thesecond largest in Africa Lagos lies between longitude2°42’Eand3°42’EandLatitude6°23’Nand6°41’N,whichisapproximately1,000sq.kminsizewithacoastlineofabout180km[13].About22%ofthetotal landmassismade upof anetwork of creeks,riversandlagoons[14].Thesoilsaremostlyhydromorphic, clayey and sandy. It contains over 70%ofNigeria’smanufacturingindustries[15]withthehighest level of estimated emission of 8000 tons ofhazardouswastesperyear.Thereareabout2000industries in Lagos metropolis with industrial units suchas chemical industries, metal industries, oil refineries,petrochemicals,tanneries,pharmaceuticals,textiles,etc of which many discharge their effluents into Shasaand Odo Iya Alaro streams in the densely populatedand heavily industrialized Ikeja suburb [16]. Due to thevast location of industries in Lagos metropolis, there isneed to analyse various types of industries in order toidentifywhichclasshasthehighestloadofpollutants.

2. MATERIALANDMETHODS

2.1 SampleCollection

Effluent samples were collected from different industrytypes namely pharmaceuticals, textiles, paints, foodsandbeverages,basicmetals,andconglomeratesaroundLagosmetropolisbetweenthe month of November, 2006 to May, 2008.Effluentsamples were collected bimonthly over a period of 20months. Polyethylene containers for effluents sampleswerewashedwithdetergent andrinsedwithwater.Thecontainersweresoakedin2Mnitricacidovernight and then washed with distilled water prior tosampling. Winkler bottles for dissolved oxygen werealsocleanedasdescribedforthepolythenecontainers. From each industry types, effluent sampleswere collected in acid washed polythene container forphysicochemical parameters while sample for heavymetals was sampled into prewashed acid polythylenecontainer and preserved with concentrated nitric acid.Sample for Dissolved Oxygen (DO) was collected withaWinkler’sbottleandpreservedwithManganousoxide/sodiumiodideazidereagent.

2.2 SampleAnalysis

Thecollectedsampleswereanalyzed forpH, TotalDissolvedSolids(TDS),alkalinity,totalhardness,sulphate, phosphate, nitrate, DO, Biochemical OxygenDemand(BOD),ChemicalOxygenDemand(COD)andheavymetalsweredeterminedintheeffluentsaccordingto[17].

2.3 QualityControl

The accuracy of the BOD and COD determination wascheckedusingstandardmixtureofglucoseandglutamicacidandpotassiumhydrogenphthalaterespectively.Theoretically,theBODshouldbeapproximately 220 mg/L and COD value of 500 mg/L.The average value of 235±39mg/L BOD obtained fromthestudywascomparable(106.8%recovery)tot he theoretical value of 220 mg/L BOD, indicating goodaccuracy. The average value of 494±34 mg/L CODobtained from the control check represented a 98.8%recovery,andagoodaccuracy.

The analytical results are expressed as mean ±SD.One-way analysis of variance (ANOVA) was used toanalyze the results at significant level of $p<0.05$ (SPSSversion19). Multivariate analysis of the data was donewith the aid of (PAST, version 1.38).Also the resultsobtainedwascomparedwithstandards limits.

3. RESULTSANDDISCUSSION

Theresultsofthephysicochemicalparametersandheavy metalsarerepresentedinTable1and2respectively.

3.1 TextileIndustry

The parameters of concern in textile Industry are pH,colour, TDS, BOD, COD and Cr. pH values rangedwithin9.2-12.6withmeanbeing10.6±1.1Thatis,these effluents were mostly alkaline in nature, and didnotmeetrequiredguidelinesof6.0-9.0.Similarly,alkaline pH values for textile effluents have been notedbyotherresearchers[18-21].Thealkalinenatureoftheeffluentswasasaresultoftheuseofsodiumhydroxide during one of the process of manufacturingtextile materials. High pH inhibits the growth of aquaticmacrophytes by impairing iron (Fe) and phosphorusuptake [22]. Cu (1.45±0.93) mg/L and Cr (2.54±0.26mg/L)valuesarehigherthanthestandardlimits[23,24]. The high levels of Cu and Cr in textile effluentscould be related to the various pigments and additivesusedinthemanufacturingoftextilematerials.

3.2 PharmaceuticalIndustry

The parameters of concern in pharmaceutical Industryare TDS, BOD and COD values, which may be in thetens of hundreds of milligrams per litre. Effluents ofpharmaceutical industries had pH range of 4.1-9.2 withmean of 6.8±1.4 (Table 1).The NO_3^- levels (78±45mg/L) are not within the standard limit of 20 mg/L [24].TheDOvalueswerelow(1.3±1.2mg/.TheBOD(150±96mg/L)andCOD(245±140mg/L)valuesexceededthestandardlimitsof30mg/Land80mg/L [23]; and 50 mg/L and 250 mg/L [24](Table 1).The release of effluents with high levels of BOD andCODintoriversorstreamwaterwillhaveadverseeffects on aquatic life due to depleted oxygen level inwater.ThehighlevelsofBODandCODcouldbeattributed to the organic nature of the raw materialsused in the industry. The TDS and BOD levels werehigherthantheworkreported[25,26].Levelsofheavy metals (Pb, Cd, Zn, Cu, Cr and Ni) were withinthe standard limits [23, 24]. However, levels of Pb, Cd,and Cr were lower than the levels reported [25, 27] butthe Cu levels (0.26 mg/L) in this study are higher than(0.15 mg/L and 0.22 mg/L) for the work carried out [25,27].The levels of the metals were lower than similarwork carried out on heavy metals concentrations insomepharmaceuticalindustrialeffluents[28-30]

3.3 PaintIndustry

The parameters of concern in paint Industry are pH,TDS,SO_4^{2-},PO_4^{3-},NO_3^-,BOD,CODandCr.ThepH values were 8.5±1.8 which ranged between 6.5-11.0.The pH was mostly basic; this could be due to the useof ammonia solution as buffer in water based paints.The values of TDS are high (1610±180 mg/L) but stillwithinthestandardlimitsof2000mg/L.TheSO_4^{2-} (577±51) mg/L and NO_3^- (67±37 mg/L) values are notwithinthelimit[23]of500mg/Land20mg/Lrespectively.

TheSO_4^{2-}andNO_3^-levelswerehighercomparedwith [31] work. The DO values were low (1.3±1.7 mg/L),while BOD and COD values exceeded the standardlimits [23, 24].The BOD and COD values were similarto the results [31] but the COD values obtained arelower compared with [20, 31] works. The presence oforganic compounds such as nitro cellulose used asthickener, alkyd resins and acrylic /styrene co-polymerused as dispersants and binders could be the cause ofhigh content of biodegradable organic matter, whichimpactstheBOD.Theavailabilityofoxidizableinorganic compounds such as pigments and additivescouldberesponsiblefor theimpactonCOD.

The metal values are lower than the standards (Table2)thoughZnvalueswerehigherthanWorldBank(1995) [24] standard. The levels of metals obtainedwerehighercomparedwiththeworkreported[32].Similar work reported by [20, 29, 31-33] gave a higherlevelsofthemetalsanalysed.Thedischargeof effluents with high levels of Zn to nearby water bodies,though unusual in that it has low toxicity to man, butrelativelyhightoxicity tofish[34].

3.4 BasicMetalIndustry

The parameters of concern in Basic Metal Industry arepH, TDS, SO_4^{2-}, NO_3^-, and metals (Zn, Cu, Cr and Ni).The pH values ranged within 5.9-12.8 with mean being8.4±2.0, the effluents were mostly basic. The BOD andCODvaluesexceededthelimits.TheNO_3^- levels(60-
±32 mg/L) are not within the FEPA (1991) [23] of 20mg/L.Thevaluesofmetalsanalysedarebelowthe [23] limitthoughZnandCuvalueswerehigherthan [24] limit. The levels of Pb, Cd, Cr and Ni were lowerthan work reported [35]. The levels of Cu (0.55±0.65mg/L) are higher compared with values obtained by[35]

3.5 Foods&BeveragesIndustry

TheparametersofconcerninFoods&BeveragesIndustry are pH, TDS, SO_4^{2-} , BOD, COD and Zn.ThepH values ranged between 3.3 - 5.4 with mean being4.0±0.9.Theeffluentsweregenerallyacidic.Theobserved mean pH of the effluent (4.0±0.9) was muchlower than pH 6.0, 8.0 and 8.3 reported for effluentsfrom NASCO, Cadbury Plc in Nigeria [36] and Dairyindustry [37]. SO_4^{2-} , PO_4^{3-}, NO_3^- and Cl^- were below thestandard limits [23, 24]. The levels of PO_4^{3-}, NO_3^- andCl^- were lower while SO_4^{2-} was higher than reportedwork [10]. The DO values were low (1.9±1.3 mg/L).BOD and COD values were about five times and fourtimesrespectivelyhigherthanthestandardlimit[23].TheDOrangeisfarbelowtherecommendedminimumof5.0mg/Lforaquaticlifeandcouldencouragesepticconditioninthewaterbodies.This condition is detrimental to aquatic life.Pb, Cd, Cu, CrandNivalueswerebelowthelimits.However,Znlevelswereabouttwotimeshigherthanthe WorldBank limit [24]. The release of effluents with high levelof Zn into water bodies will have effect on the aquaticlife[32].

3.6 ConglomerateIndustry

pHvaluesrangedwithin5.0-7.1withmeanbeing6.0±0.7. The pH values are slightly acidic. The acidicnature of the effluent could be attributed to the natureof the raw material used for the manufacturing of thevariousproducts,whichincludesrangeofsoaps,cosmetic products, pharmaceutical, etc. The pH valuesaresimilartoworkdone[38].TheDOvalues0.85±0.74mg/Larelow,whichsuggestedthattheindustry was releasing some organic substances thatwere high oxygen-demanding wastes [3], thus cannotsupport aquaticlife. The BOD values arefivetimesand three times higher than the standard limits [23, 24]while COD values are three times higher than standardlimit [24]. Pb, Cd, Zn, Cu, Cr and Ni values werebelow the standard limits [23, 24]. The levels of metalswerelowercomparedtotheworksdone[38,39].However, continues discharge of effluent with low levelof metal will pose a great danger to the receiving waterbodies,itsinhabitants(fishesandotheraquaticorganisms)aswellasthosewhomakeuseofthewaterfor directdomestic purposes.

Analysisofvariance(p=0.05)showssignificantdifferenceamongthetypesofindustriesforpH,conductivity,TDS,alkalinity,Ca,totalhardness,sulphate,nitrate,dissolvedoxygen,Pb,Cd,Zn,Cu,Cr and Ni indicating constituent concentration variedspatiallyandtemporally.LevelsofMg,phosphate,chloride,biochemicaloxygendemandandchemicaloxygendemanddidnotshowsignificantdifferenceamongthetypes ofindustries.

3.7 Multivariate Analysis for Heavy Metals inTypesof Industry

PrincipalComponentAnalysis(PCA)wasusedtocategorize the various types of industries according tothe similarities in the heavy metal levels. PCA of heavymetal for six effluents types indicated that the first twocomponents (PC1 and PC2) accounted for 97.5% ofthetotalvariation(Table3).Aplotofthefirsttwocomponentsshowedfourdifferentgroupscharacterized by their metal concentrations. Cluster 1wascharacterizedbyfood&beveragestypesofeffluentwiththehighestZnconcentrations,cluster2bypharmaceuticals,andconglomeratetypesofeffluentswithleastmetal(Pb,Cd,Cu,CrandNi)concentrations,cluster3byPaintandBasicmetaltypesofeffluentswithhighestNiandCdconcentrations and finally cluster 4 with Textile type ofeffluentswiththehighestmetal(Pb,CuandCr)concentrations. From the PCA biplot (Figure 1.), textiletypes of effluents stand to contribute Pb, Cu and Cr tothe environmental media. Cluster formed by the PCAwere confirmed by the cluster analysis dendrogram in(Figure2.),wherefourdifferentclusterswerenoticed. Cluster1dominatedbyfood&beveragestypes ofeffluent;cluster2bypharmaceuticals,andconglomerate types of effluents having similar metalconcentrations;cluster3bypaintandbasicmetaleffluents having very similar metal concentrations andfinallycluster 4withtextileeffluents.

Generally, textile effluents have the highest load of themetal studied while the foods & beverage effluent hadthe least concentrations of the metal studied except Znconcentrations. The order of the metal concentrationsin the types of effluents studied is textile > paint andbasic metal > pharmaceuticals, and conglomerate >foods&beverages.

Table1.Physicochemicalcharacteristicsofeffl uentsfromdifferentclassesofindustries.

Effluenttypes/ Parameters	pH	TDS	Alkalinity	Total Hardness	SO_4^{2-}	PO_4^{3-}	NO_3^-	DO	BOD	COD
Textile	10.6 ±1.1	1160 ±890	316 ±270	40 ±32	156 ±73	0.99 ±0.29	60 ±32	1.8 ±1.7	209 ±72	343 ±130
Pharmaceuticals	6.8 ±1.4	633 ±260	233 ±97	53 ±44	34 ±36	0.65 ±0.57	78 \±45	1.3 ±1.2	150 ±96	245 ±140
Paint	8.5 ±1.8	1610 ±180	216 ±120	60 ±33	577 ±51	0.90 ±0.13	67 ±37	1.3 ±1.7	221 ±130	367 ±150
Basicmetals	8.4 ±2.0	532 ±280	220 ±240	70 ±38	71±53	1.09±0.80	61±50	2.7±1.5	194±81	330±120
Food&beverage	4.0 ±0.9	477 ±150	94±35	**	172±19	0.57±0.21	15.9±2.5	1.9±1.3	147±75	269±140
Conglomerate	6.0 ±0.7	385 ±60	128 ±56	71 ±32	10.3 ±8.2	0.97 ±0.49	106 ±23	0.85 ±0.74	136 ±120	246 ±180
FEPA(1991)	6.0-9.0	2000	NA	NA	500	5	20	NA	30	80
WorldBank (1995)	6.0-9.0	NA	NA	NA	NA	NA	NA	NA	50	250

*All units in mg/L except pH with no unitNA–notavailable; **notdetermined,

Table2.Levels of heavy metal (mg/L)characteristics* of effluents from different classesofindustries

Effluent types/Parameters	**Pb**	**Cd**	**Zn**	**Cu**	**Cr**	**Ni**
Textile	0.28±0.09	0.01±0.00	0.67±0.29	1.45±0.93	2.54±0.26	0.06±0.04
Pharmaceuticals	0.053±0.042	0.012±0.013	0.48±0.20	0.048±0.033	0.030±0.024	0.043±0.021
Paint	0.08±0.12	0.007±0.003	0.69±0.14	0.48±0.08	0.02±0.00	0.04±0.00
Basicmetals	0.11±0.08	0.009±0.004	0.62±0.24	0.55±0.65	0.09±0.10	0.06±0.04
Food&beverage	0.04±0.02	0.003±0.002	0.92±0.16	0.02±0.02	0.01±0.00	0.04±0.04
Conglomerate	0.03±0.03	0.04±0.12	0.25±0.10	0.22±0.10	0.01±0.00	0.05±0.04
FEPA(1991)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
World Bank(1995)	0.1	0.1	0.5	0.5	0.1	0.5

Table 3: Principal component analysis of data ofindustrialeffluent metalconcentration

	Eigen Values	Percentage variance	Cumulative percentage
PC1	1.30625	93.894	93.894
PC2	0.0499	3.5867	97.481
PC3	0.03482	2.5031	99.9841
PC4	0.00019	0.01342	99.9838
PC5	3.52E-05	0.00253	99.9975
PC6	-4.04E-16	-2.90E-14	-

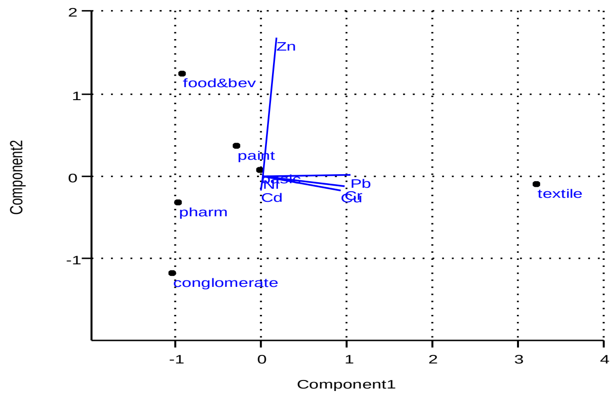

Fig.1. Principal component biplot of data oneffluentsmetalsconcentrations.

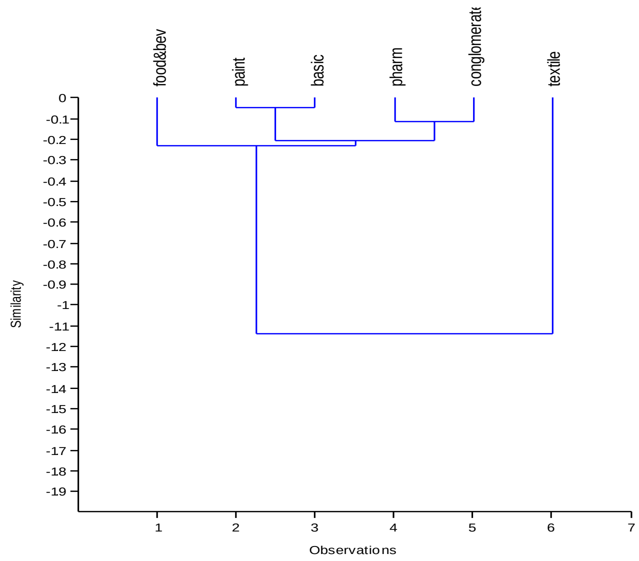

Fig.2. Cluster analysis dendrogram of effluentstypesforsixmetalconcentrations

4. CONCLUSION

Most of the effluents analyzed from the various effluenttypesinLagos,Nigeriahadhighlevelsofnitrate,Chemical Oxygen Demand and Biochemical OxygenDemand, which is indicative of a high level of grossorganicpollution,andlikelihoodtocauseeutrophicationofreceivingwaterbodies.Chromiumand copper werealso problematicin textileeffluents.In most cases, the characteristics of the effluents didnotmeettherequiredlimitingguidelinesoftheregulatory agency in Nigeria. However, the textile andpharmaceutical industrial sector tended to dischargethemostpollutedeffluents.

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