Influence of discharged industrial effluents on the parameters of surface water in Onitsha urban area, southeastern Nigeria

Michael C. OBETA1) AD, Uchenna P. OKAFOR2) BCE ☉ , Cletus F. NWANKWO3) F

University of Nigeria, Department of Geography, Nsukka Road, 410001 Nsukka, Nigeria
1) orcid.org/0000-0001-5380-1379; e-mail: michael.obeta@unn.edu.ng
2) orcid.org/0000-0002-3621-1665; e-mail: uchenna.okafor@unn.edu.ng
3) orcid.org/0000-0003-0071-4903; e-mail: cletus.nwankwo@unn.edu.ng

For citation: Obeta M.Ch., Okafor U.P., Nwankwo C.F. 2019. Influence of discharged industrial effluents on the parameters of surface water in Onitsha urban area, southeastern Nigeria. Journal of Water and Land Development. No. 42 (VII–IX) p. 136–142. DOI: 10.2478/jwld-2019-0054.

Abstract

Chemical industries in Onitsha urban area of southeastern Nigeria have been discharging large quantities of effluents into surface streams. These streams are the primary sources of water used by poor households for domestic purposes. This study examines the effects of effluents on the physicochemical and microbiological characteristics of the recipient streams. This objective was achieved by collecting eight effluents and twenty-two water samples from control points, discharge locations and exit chutes of the effluents for analysis. The results of the study characterised the effluents and their effects on the recipient streams. The effluents cause gross pollution of the streams as most of the parameters including pH, total dissolved solids (TDS), turbidity, biological oxygen demand (BOD), chemical oxygen demand (COD), Mg, NO₃, Fe, Cu, Pb, Cr, total heterotrophic count (THC) and total coliform group (TCG) returned high values that exceeded the World Health Organisation’s (WHO) benchmark from 2011 for drinking water quality. Only dissolved oxygen (DO), Na, Zn, Ca, and Na returned values lower than the WHO guideline. E. coli was found in all the samples; TCG was also high. This paper, therefore, recommends that the effluent generating industries should treat their effluents before disposal.

Key words: drinking water supplies, industrial effluents, streams contamination, water quality

INTRODUCTION

Industrial and urban wastes, as well as extensive use of chemical fertilizers in agriculture, have contributed significantly to the growing deterioration of water quality across the globe [ATTOUNI et al. 2016]. Industrial wastes constitute growing problems for water quality and pose a severe danger to the recipient environments [BOUSSAH, LAIFA 2017]. This study concerns the impact of one of the contaminants of surface water bodies in Onitsha urban, Nigeria. The focus is on the effect of industrial effluents on parameters of surface water in the study area. Industrial effluents refer to the liquid wastes that are generated from industries as a result of the production activities within the industries [UCHEGBU 2002]. There are deleterious effects of discharged industrial effluents on the physicochemical and microbiological characteristics of surface water bodies [OKAFOR 2017].

Industrial wastes contain toxic and hazardous substances, most of which are detrimental to human health. Examples of some harmful pollutants contained in industrial effluents discharges include lead, cadmium and mercury (heavy metals) and toxic organic chemicals such as pesticides, polychlorinated biphenyls (PCBs), dioxins, polyaromatic hydrocarbons and phenolic compounds [UCHEGBU 2002]. These wastes are generally residues of either uniform or diverse composition; and they have been found to be of various degrees of toxicity [ECHIEGU, LIBERTY
The assessment of the influence of point-source pollutants in surface water quality has become increasingly important [ATTOU et al. 2016]. The investigation of the level of contaminations of the polluted rivers and the impacts of the pollution on the quality of the streams is pertinent because of the critical development roles these water resources play [MOSIE et al. 2007].

In many developing countries, including Nigeria, liquid industrial effluents are discharged directly into surface water bodies such as streams or lakes [ECHIEGU, LIBERTY 2013; OKAFOR 2017]. When this happens, the human society pays a high price for improper disposal of industrial wastes since the polluted water are mainly used for both domestic and drinking purposes by human population resident within the vicinity of the surface water bodies [AMADI 2012; OKAFOR 2017]. In Amazon, Brazil, for instance, Dimario [2004] reported that prospecting for gold resulted in rivers and fish being contaminated severely with mercury used in the refining process in the country. Kupchella and Hyland [1993] also described the effects of acetaldehyde and chloride discharged from a factory into Mina-Mata Bay in Japan in the 1950s which killed many animals such as dogs, cats and pigs involved in the consumption of water extracted from Mina-Mata Bay. In 1958, when the number of victims exceeded 50 people, 21 of whom died, a ban was placed on the sale of fish from Mina-Mata Bay, though there was no restriction on disposal of industrial effluents on surface waters. In India, industrial effluents discharged into surface streams were also reported to pose severe threats to human health [MASON 1992].

In Nigeria, the disposals do not always comply with pretreatment requirements [ECHIEGU, LIBERTY 2013; OKAFOR 2017]; less than 10% of industries treat their effluents before being discharged, usually into rivers [ECHIEGU, LIBERTY 2013]. Consequently, there is a high load of inorganic and hazardous metals such as lead (Pb), chromium (Cr) and iron (Fe) in many of the receiving water bodies. AMADI [2012] observed that indiscriminate disposal of industrial wastes in Nigeria remains a significant threat to surface water quality. Osibando [2000] highlighted that after a survey of the backlog of Nigeria’s environmental problems from independence in 1960, the Federal Environmental Protection Agency (FEPA) in 1990 identified industrial waste as a significant ecological problem requiring urgent attention. Although there are policies and laws which guide and control the production and management of industrial wastes because of their hazardous nature in Nigeria [UCHEGBU 2002]; the low compliance to and the non-enforcement of the regulatory laws, has led to the improper disposal of industrial effluents both in urban and rural areas [MOZIE, AYADIUNO 2008].

This study aims to examine the effects of disposing of liquid effluents from industries into streams in Onitsha urban of southeastern Nigeria. The study characterised the liquid effluents discharged by industries in the area and established their harmful effects on the quality of the receiving water bodies. It is hoped that the results of this study will assist relevant state agencies in designing mitigation measures to ensure that the quality of the water in the streams of the study area is protected from the adverse effects of effluents from industries. The results may also contribute to the knowledge base for future research on the management of liquid effluents discharged from industries in urban areas of a developing country like Nigeria.

THE STUDY AREA

Onitsha urban area is located between latitude 6°07’–6°09’N and longitude 6°47’–6°48’E. It is situated at the bank of the Niger River in Anambra State, southeastern, Nigeria. The urban area covers about 50 km² and is accessed through the East-West national main road from Lagos through Benin which links the eastern-north-south route via the Niger Bridge at Onitsha [MOZIE 1992]. Onitsha lies at the major east-west crossing point of the Niger River and occupies the northern end of the river that is regularly navigable by large vessels. These factors have historically made Onitsha a major centre for trade between eastern and western Nigeria. Also the favourable site of Onitsha, as a meeting point of two different regions, providing the link between the savanna of the North and the delta region of the South enabled Onitsha to develop into an important commercial and manufacturing centre. The urban area is now an economic nerve centre and the industrial hub of southern Nigeria. Most of the industries operating in Onitsha are without waste water treatment. Effluents are routinely discharge directly into nearby streams or on open surfaces. Unfortunately, the disposal or discharge of effluents is not stringent regulated by state or federal authorities. These discharged effluents deter beneficial uses of the receiving streams for domestic, industrial and agricultural water uses.

Fig. 1. Sample points for all the water samples collected in the study area; source: own elaboration
The city is split up into two local government areas namely, Onitsha North and Onitsha South local government areas. Ogbaru and Idemili North bound Onitsha in the South and the East respectively. The climate of the study area belongs to THORNTWAITE’S [1948] humid forest mega thermal climate which ILOEJE [1972] regards as sub-equatorial and INYANG [1975] classified as 8-month rainy season climate. The principal geologic units of the area are the recent deposits of the Holocene (Quaternary) occupying the active floodplains of the Niger and Anambra Rivers and the sandstone formations of the Upper-Middle Eocene (Tertiary) occupying the sandstones plains lying above and adjacent to the Niger-Anambra floodplains. The landscape of Onitsha urban area is lowland. Topographically, the area is traversed and drained mainly by the Niger River and its tributaries notably, the Idemmili and Nkisi Rivers all draining into the Niger River. The relief of Onitsha has made floodplains found in this area to be depositional. Lakes and ponds and levees pockmark the relief of the study area. The sandstone formation constitutes aggradations plains [OFOMATA 1975].

MATERIALS AND METHODS

Forty-seven (47) chemical industrial plants currently discharge their effluents into surface water bodies in Onitsha urban area. These industries were classified into eight groups; according to their production processes. One industrial plant, representing a category of the production process was chosen purposively from each of the eight groups for this study. The criteria for selection included availability for research, accessibility to exit chutes of wastes, and time of effluent discharges. Eighteen water quality parameters, including temperature, pH, dissolved oxygen (DO), nitrate, turbidity, total dissolved solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD), copper, calcium, iron, zinc, chromium, magnesium, sodium, lead (Pb), total heterotrophic count (THC), and total coliform group (TCG) were investigated. The pH value of a water sample measures its hydrogen ion concentration and indicates whether the sample is acidic, neutral or basic [ABABIO 1990]. Turbidity is a measure of transparency (clarity) or the cloudiness of water due to fine suspended colloidal particles of clay or silt, waste effluents or microorganisms contained in water while total dissolved solids (TDS) is the measure of the combined dissolved content of all organic and inorganic substances present in water. Nitrate is a compound of nitrogen oxidation which shows the effect of organic pollution on water quality [AGBAZUE, AKPANISI 2012] while DO refers to dissolved oxygen i.e. oxygen gas molecules present in water. Chemical oxygen demand (COD) is the amount of oxygen consumed under specific conditions of organic and oxidizable inorganic matter in wastewater [AGBAZUE, AKPANISI 2012; AGUWAMBA 2000] while biological oxygen demand (BOD) is the amount of oxygen required by bacteria to stabilise decomposable organic matter under aerobic conditions [AGBAZUE, AKPANISI 2012; AGUWAMBA 2000]. Sodium is a common element in the environment and occurs widely in soils, plants, water and foods [AGBAZUE, AKPANISI 2012]. Calcium is an essential dietary mineral for cell physiology and bone formation. Calcium is required for both strong bones formation and formation and migration of blood clotting [EMMANUEL et al. 2009].

Magnesium is the fourth most abundant cation in the human body and the second most abundant cation in intracellular fluid [UN WATER 2011]. Zinc is an essential trace element needed by the human body [OCHERI et al. 2008]. Heterotrophic microorganisms are those organisms that obtain their food by feeding on organic substances for nourishment [BROOKS et al. 1998]. These organisms cannot make their food but are dependent on other substances for nutrition [BROOKS et al. 1998]. For example, bacteria, yeast and moulds are heterotrophic. The total heterotrophic count (THC) is used to estimate the number of live heterotrophic bacteria that are present in a water sample. THC provides useful information about water quality and supporting data on the significance of the coliform test results [KEHINDE 1996]. Total coliform group (TCG) are a collection of relatively harmless microorganisms that live in large numbers in the intestine of man and other animals [TAIWO 2011]. They aid in food digestion. The presence of fecal contamination is an indication that a potential health risk exists for individuals exposed to this water [TAIWO 2011].

The choice of these parameters was informed by the ease of interpretation, their association with industrial effluents and effects on human health. Eight (8) discharged effluents samples were collected from the exit chutes of the effluents at each of the sampled industrial plants; while 6 water samples were collected up-stream (at 3 control points) from the sampled streams (the Niger River, the Nkisi River, and the Idemmili River) about 100 m away before the discharge locations. Two samples (one for physicochemical analyses and the other for microbiological analyses) were collected at each location according to recommended standard procedures for water quality analysis by American Public Health Association [APHA 1998]. Sixteen water samples were collected at the 8 effluents discharge locations (i.e. the point where the effluent enters the surface. Two water samples were collected per location, from the 8 different discharge locations. The effluent samples were collected during the period of heavy activity corresponding to the times when high volumes of effluents are discharged. The fieldwork involves collecting the samples aseptically in bottles with capacity of 2 dm³. The samples were then placed in insulated containers and transported to the Water Science Laboratory of the Department of Microbiology, University of Nigeria, Nsukka for analyses. The temperature was measured directly using a glass thermometer, and pH was measured using the pH-meter.

RESULTS AND DISCUSSION

The results of the laboratory analysis of the liquid effluents collected from the exit chutes of the effluents of the sampled industries are presented in Table 1. The findings on the physicochemical and microbiological properties of
discharged effluents evaluated in this study are summarised in Table 1. As shown in Table 1, the concentration levels of most of the parameters analysed exceeded the WHO [2011] benchmark for drinking water supplies at several sampling locations. A summary result of the physicochemical and microbiological characteristics of the recipients’ stream based on parameter loadings of water samples obtained at the control sites is presented in Table 2. As shown in Table 2, the values returned by eight parameters (temperature, turbidity, DO, iron, lead, chromium, THC and TCG) exceeded the WHO [2011] benchmark safe limits for drinking water supplies at one or more sampling locations. Chromium was higher than the maximum permissible level set by the WHO at only one control site; the values returned by the other parameters were within the safe limits for safe drinking water when compared with the WHO [2011] benchmark. These findings show that the water quality in the streams, even before contacts with industrial effluents, did not meet safety benchmark set the WHO at all the sampling locations.

Summary information on the quality status of the recipients’ stream waters at the eight discharge locations are presented in Table 3. The results derived from these locations were used to determine the effects of the effluents on water quality of water from the recipients’ streams. As Table 3 shows, the number of parameters and sampling stations with elevated values highly increased when compared with the control points. Except for a few parameters (sodium, calcium, zinc, nitrate, dissolved solids, turbidity and pH), all other parameters returned values which exceeded the WHO [2011] standard benchmarks for drinking water supplies. This shows that the level of contamination of the water in the streams worsened and this can be attributed to the impacts of the effluents discharged at those locations. Therefore, we conclude that the high concentration values returned by most parameters are indications of the effects of the effluents on the sampled streams. The effluents worsened the level of stream water pollution, making them further unsuitable for human uses. The ranges of the values returned by each of the sampled parameters and their implications for human consumption and aquatic life are discussed parameter by parameter below.

Table 1. Physico-chemical and microbiological characteristics of effluents discharged from various industries in the study area

| Parameter     | Measurement unit | SL1 | SL2 | SL3 | SL4 | SL5 | SL6 | SL7 | SL8 |
|---------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Temperature   | °C               | 32  | 30  | 30  | 34  | 32  | 34  | 29  | 32  |
| pH            | –                | 5   | 7.5 | 6.5 | 12  | 6.5 | 6   | 6   | 5.5 |
| Turbidity     | NTU              | 200 | 320 | 200 | 150 | 100 | 200 | 110 | 310 |
| DO            | mg dm⁻³          | 5.11| 3.32| 3.48| 5.07| 5.42| 3.21| 3.39| 4.26|
| TDS           | mg dm⁻³          | 5.8 | 1.1 | 3   | 1.7 | 2.8 | 0.8 | 0.7 | 6.10|
| COD           | mg dm⁻³          | 51.9| 7.9 | 0.36| 51.9| 6.9 | 38.9| 39.9| 1.08|
| BOD           | mg dm⁻³          | 14.4| 31.43|13.17|32.02|0.16|0.48|2.06|41.9 |
| Nitrate       | mg dm⁻³          | 1.24| 0.32| 0.54| 1.31| 0.61| 0.82| 0.52| 0.15|
| Iron          | mg dm⁻³          | 0.52| 0.02|    | 0.82| 0.92| 0.4 | 0.76| 0.84|
| Zinc          | mg dm⁻³          | 0.03| 0.07| 0.26| 0.14| 0.14| 0.01| 0.70| 0.18|
| Copper        | mg dm⁻³          | 0.72| 0.56| 1.68| 1.68| 1.68| 0.72| 0.66| 0.02|
| Magnesium     | mg dm⁻³          | 2.90| 0.50| 0.43| 0.32| 0.35| 2.5 | 0.08| 0.09|
| Calcium       | mg dm⁻³          | 8.23| 12.46|1.92|1.12|0.32|0.74|0.60|8.24 |
| Sodium        | mg dm⁻³          | 3.29| 2.54| 0.14| 1.24| 1.24| 0.08| 2.41| 6.29|
| Chromium      | mg dm⁻³          | ND  | 0.18| 0.018|0.008|0.06|0.14|ND  |ND  |
| Lead          | mg dm⁻³          | ND  | 0.32| 0.33| 0.01| 1.44| 0.06| ND  | ND  |
| THC           | Cfu (100 cm⁻³)⁻¹| 14  | 8   | 13  | 24  | 45  | 14  | ND  | 6   |
| TCG           | Cfu (100 cm⁻³)⁻¹| 3   | 5   | 2   | 1   | 12  | 3   | ND  | 2   |

Explanations: SL1–SL8 as in Fig. 1; DO = dissolved oxygen, TDS = total dissolved solids, THC = total heterotrophic count, TCG = total coliform group, ND = not detected, bolded values = exceeded WHO standard [WHO 2011].

Source: own study.

Table 2. Physico-chemical and microbiological characteristics of the recipient surface waters (control), 500 m before contact with effluents

| Parameter     | Measurement unit | 1 – the Niger River | 2 – the Idemili River | 3 – the Nkisi River | WHO standard [WHO 2011] |
|---------------|------------------|---------------------|-----------------------|---------------------|-------------------------|
| Temperature   | °C               | 24                  | 28                    | 26                  | 25                      |
| pH            | –                | 7.2                 | 6.5                   | 7.10                | 6.5-8.0                 |
| Turbidity     | NTU              | 100                 | 300                   | 300                 | 5.0                     |
| DO            | mg dm⁻³          | 136                 | 93                    | 96                  | 6.0                     |
| TDS           | mg dm⁻³          | 176                 | 330.2                 | 318.10              | 500                     |
| COD           | mg dm⁻³          | 4.00                | 3.60                  | 5.90                | 10                      |
| BOD           | mg dm⁻³          | 2.08                | 5.2                   | 7.2                 | 10                      |
| Nitrate       | mg dm⁻³          | 0.10                | 0.28                  | 0.12                | 50                      |
| Iron          | mg dm⁻³          | 0.02                | 1.41                  | 1.42                | 0.3                     |
| Zinc          | mg dm⁻³          | 0.03                | 0.06                  | 0.07                | 3                       |
| Copper        | mg dm⁻³          | 0.10                | 0.22                  | 0.10                | 1                       |
| Magnesium     | mg dm⁻³          | 1.03                | 0.07                  | 0.12                | 0.2                     |
| Calcium       | mg dm⁻³          | 2.29                | 7.1                   | 2.8                 | 75                      |
| Sodium        | mg dm⁻³          | 1.17                | 0.04                  | 0.98                | 200                     |
| Chromium      | mg dm⁻³          | 0.008               | 0.0025                | 0.002               | 0.003                   |
| Lead          | mg dm⁻³          | 0.048               | 0.0041                | 0.002               | 0.01                    |
| THC           | CFU (100 cm⁻³)   | 28                  | 42                    | 37                  | 10                      |
| TCG           | CFU (100 cm⁻³)   | 20                  | 31                    | 19                  | 0                       |

Explanations: DO, TDS, THC, TGC as in the Table 1.

Source: own study.
Table 3. Physico-chemical and microbiological characteristics of water samples in rivers

| Parameter | Measurement | SL4 | SL8 | SL2 | SL3 | SL1 | SL5 | SL6 | SL7 | WHO standard [WHO 2011] |
|-----------|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-------------------------|
| Temp      | °C          | 26  | 28  | 29  | 30  | 30  | 28  | 30  | 29  | 25                      |
| pH        |             | 8.2 | 7.5 | 6.80| 6.5 | 7   | 6.9 | 6.7 | 7.2 | 6.5–8.0                 |
| Turbidity | NTU         | 100 | 100 | 300 | 300 | 300 | 300 | 400 | 300 | 500                     |
| DO        | mg dm⁻³      | 130 | 143.6| 78.34| 82.16| 90.18| 35 | 62.85| 89.42| 6.0                     |
| TDS       | mg dm⁻³      | 176.8| 126.10| 331.40| 303 | 326.27| 318.80| 435.12| 312.27| 500                     |
| COD       | mg dm⁻³      | 3.97 | 2.08 | 4.19 | 3.60 | 53.9 | 5.90 | 18.9 | 39.9 | 10                      |
| BOD       | mg dm⁻³      | 3.12 | 41.9 | 5.9 | 13.17| 14.6 | 4.7 | 21.9 | 20.6 | 10                      |
| Nitrate   | mg dm⁻³      | 0.17 | 0.15 | 0.12 | 0.54 | 1.28 | 0.23 | 0.68 | 0.52 | 50                      |
| Iron      | mg dm⁻³      | 0.14 | 1.84 | 0.04 | 0.02 | 0.56 | 0.40 | 0.52 | 0.76 | 0.3                     |
| Zinc      | mg dm⁻³      | 0.01 | 0.18 | 0.1 | 0.26 | 0.04 | 0.26 | 0.16 | 0.70 | 3                       |
| Copper    | mg dm⁻³      | 0.30 | 0.02 | 0.10 | 1.68 | 0.68 | 0.20 | 0.40 | 0.66 | 1.5                     |
| Magnesium | mg dm⁻³      | 0.86 | 3.09 | 0.12 | 0.43 | 2.46 | 0.33 | 0.28 | 0.18 | 0.2                     |
| Calcium   | mg dm⁻³      | 2.68 | 8.24 | 5.2 | 4.92 | 6.12 | 5.48 | 3.04 | 0.60 | 75                      |
| Sodium    | mg dm⁻³      | 2.02 | 6.29 | 0.98 | 0.14 | 2.69 | 2.08 | 2.68 | 2.41 | 200                     |
| Chromium  | mg dm⁻¹      | 0.018 | 0.032 | 0.014 | 0.018 | ND | 0.0162 | 0.0418 | 0.022 | 0.003                  |
| Lead      | mg dm⁻¹      | 0.04 | 0.082 | 0.028 | 0.033 | ND | 0.028 | 0.076 | 0.074 | 0.01                   |
| THBC      | Cfu (100 cm⁻³)⁻¹ | 30 | 62 | 68 | 53 | 26 | 61 | 76 | 43 | 10                      |
| TCGC      | Cfu (100 cm⁻³)⁻¹ | 23 | 38 | 46 | 42 | 32 | 46 | 73 | 30 | 0                       |

Explanations: bolded values exceeded the WHO [2011] minimum benchmark for drinking water; other explanations as in Tab. 1.
Source: own study.
tration value of 1.68 mg∙dm$^{-3}$ while the lowest copper concentration value of 0.02 mg∙dm$^{-3}$ was recorded in SL8.

The presence of chromium in drinking water is a significant health threat because of the carcinogenic effects of chromium content in water. SL3 and SL4 returned relative highest values of 0.18 mg∙dm$^{-3}$ for chromium while SL1 returned non-detectable value of chromium in the analysed samples. SL6, returned the highest value of 0.0418 mg∙dm$^{-3}$ while SL5, SL7 and SL8 returned values of chromium that were also above the WHO [2011] recommended limits for domestic water consumption in the analysed samples. The varying levels of zinc concentrations in analysed water samples reveal that the SL7 returned the highest concentration level of 0.70 mg∙dm$^{-3}$ for zinc while SL4 returned the lowest concentration value of 0.01 mg∙dm$^{-3}$.

The results of our analysis of THC show that all the surface water bodies studied (except SL7) returned THC levels well above WHO standard limits for drinking water supplies. All the water samples analysed (except SL7 again) returned TCG counts well above the WHO [2011] standard limits for drinking water supplies except SL7.

**CONCLUSIONS**

Contamination of surface waters represents a growing environmental health challenge in several regions around the globe. In this study, industrial effluents consisting of toxic substances such as nitrate, lead, chromium, and other pollutants worsened the level of stream water contamination in the study area. Generally, this development is a source of public concern, especially in our study area where surface water bodies account for a high proportion of people’s water needs. Although some of the parameters tested returned mean values, which were below the WHO [2011] limits for consumption, industrial effluents impact on stream water quality negatively in the study area. Thus, it is still a severe problem that needs to be addressed because of the importance of the streams as a primary source of drinking water to so many households in the area. It is hoped that this research will aid appropriate state authorities in designing mitigation measures to ensure that the quality of the water in the streams of the study area is protected from the adverse effects of effluents from industries. The paper contributes to knowledge by adding to available literature on source water protection from industries in urban areas of a developing country like Nigeria.

**REFERENCES**

AMADI D.O. 2012. Quality assessment of Aba River using heavy metal pollution index. American Journal of Environmental Engineering. Vol. 2. No. 1 p. 45–49.

APHA 1998. Standard methods for the examination of water and waste water. 20th ed. Washington D.C. American Public Health Association. ISBN 0875532357 pp. 1325.

ATTOU B., TOUMI N., MESSAOUDI S., BENRAH S. 2016. Degradation of water quality: The case of plain west of Annaba (northeast Algeria). Journal of Water and Land Development. No. 31 p. 3–10. DOI 10.1515/jwld-2016-0031.

BOUSSAHSA S., LAIFA A. 2017. Wadi Boumoussa's waters quality in the north-east of Algeria: Statistical treatment of some physical and chemical parameters. Journal of Water and Land Development. Vol. 34 p. 77–83. DOI 10.1515/jwld-2017-0040.

BROOKS G., BUTEL J.S., MORSE S.A. 1998. Jawetz, Melnick, and Adelberg's Medical Microbiology. Stanford, Connecticut. Appleton and Lange Medical Book. ISBN 0838563163 pp. 752.

DI-MARIO W.D. 2004. Risk assessment of domestic and industrial effluent unloaded in fresh water environment. Journal of Environment. Vol. 10 p. 65–67.

ECHIEGU E.A., LIBERTY J.T. 2013. Effluents characteristics of some selected food processing industries in Enugu and Anambra States of Nigeria. Journal of Environment and Earth Science. Vol. 3. No. 9 p. 46–54.

EMMANUEL V., SILVA-FILHO R.G., SOIRAL B., CHRISTOPHE-EMBLANCH B., BLAVOUV S.M.R., JULIO V.W. 2009. Ground-water chemical characterization of a Rio de Janeiro coastal aquifer SE-Brazil. Journal of South American Earth Science. Vol. 127 p. 100–108.

EZERONYE O.U., UBALUA A.O. 2004. Studies on the effects of abattoir and industrial effluents on the heavy metal and microbial quality of Aba River in Nigeria. African Journal of Biotechnology. Vol. 14. No. 3 p. 266–272.

ILLOJE N.P. 1972. A New geography of West Africa. Harlow, Essex. Longman Group Ltd., Longman House, Burnt Mill. ISBN 0582602823 pp. 172.

INYANG P.E.B. 1975. Climate regions. In: Nigeria in maps. Ed. G.E.K. Ofomata. Benin City. Ethiope Publishing House p. 27–29.

KEHINDE M.O. 1996. Impact of Industrial growth on groundwater quality and availability: A case study of Ikeja industrial area. In: Current issues in Nigerian environment. Ed. M.O. Kehinde. Ibadan. Davidson Press Ltd. ISBN 978-2754-84-5 p. 35–41.

KUPCHELLA C.E., HYLAND M.C.1993. Environmental science, living with the systems of nature. 3rd ed. Prentice Hall International Edition. ISBN 0130274186 pp. 579.

MOSIEJ J., KOMOROWSKI H., KARCZMACZYK A. 2007. Factors affecting water quality in degraded sewage receivers – case study of the phosphorus dynamics in the Ner River. Journal of Water and Land Development. No. 11 p. 103–116.

MOZIEJ A.T. 1992. Terrain evaluation for urban development purposes in Onitsha and environment. M.Sc. Thesis. Nsukka. Department of Geography, University of Nigeria pp. 214.

MOZIEJ A.T., AYADUNU R.U. 2008. The role of government in the degradation of the landscape in Onitsha and its environs: Present state and future expectations. Nigerian Journal of Geography and the Environment. Vol. 1 p. 119–127.

OCHIERI M.I., MILE Y., OKLO A. 2008. Nitrate contamination of shallow wells in Makurdi urban area of Benue State. In: Proceedings of 50th Annual Conference of the Association of Nigeria Geographers. 25–28.08.2008. Calabar. Univ. of Calabar p. 72–81.

OGHENKEKABAROH A.R. 1997. Biology and chemical assessment of the water quality of Ikeja – Opebi link stream. B.Sc. Project. Lagos. Univ. of Lagos p. 12–36.

OFOMATA G.E.K. 1975. Nigeria in maps: Eastern States.Benin City. Ethiope Publishing House. Rib ID 1556979 p. 25–36.

OFOMATA G.E.K. 1978. Landforms. In: Nsukka environment. Ed. G.E.K. Ofomata. Onitsha. Fourth Dimension Publishers p. 8–12.

OKAFOR J.U.P. 2017. Effects of industrial effluents on stream water quality in Onitsha urban area of Anambra State, Southeastern, Nigeria. M.Sc. Thesis. Nsukka. Department of Geography, University of Nigeria pp. 14.
STRESSZCZENIE

Przemysł chemiczny na obszarze miejskim Onitsha w południowowschodniej Nigerii odprowadza duże ilości ścieków do strumieni. Strumienie te są podstawowym źródłem wody dla ubogich gospodarstw domowych. W pracy analizowano wpływ ścieków przemysłowych na fizyczne, chemiczne i mikrobiologiczne właściwości wody w strumieniach. Cel ten osiągnięto, pobierając próby wody do analiz z 8 odpływów, z 22 punktów kontrolnych i miejsc zrzutu. Wyniki charakteryzują odpływy i ich wpływ na wody odbiornika ścieków. Zrzuty ścieków powodowały znaczne zanieczyszczenie strumieni, ponieważ większość parametrów (pH, zawiesiny, mętność, BZT, ChZT, Mg, NO₃, Fe, Cu, Pb, Cr, suma bakterii heterotroficznych, bakterie grupy coli) przekraczała normy jakości wody pitnej ustalone przez WHO w 2011 r. Jedynie stężenie rozpuszczonego tlenu, Na, Zn, Ca i Na spełniały te normy. Obecność E. coli stwierdzano we wszystkich próbkach, duże były także wartości stężenia bakterii grupy coli. Zaleca się, aby zakłady przemysłowe poddawały ścieki oczyszczaniu przed ich zrzutem do strumieni.

Słowa kluczowe: jakość wody, ścieki przemysłowe, zanieczyszczenie strumieni, źródła wody pitnej

Michael C. OBETA, Uchenna P. OKAFOR, Cletus F. NWANKWO

Wpływ zrzucanych ścieków przemysłowych na parametry wód powierzchniowych na obszarze miejskim Onitsha w południowowschodniej Nigerii

STRESSZCZENIE

Przemysł chemiczny na obszarze miejskim Onitsha w południowowschodniej Nigerii odprowadza duże ilości ścieków do strumieni. Strumienie te są podstawowym źródłem wody dla ubogich gospodarstw domowych. W pracy analizowano wpływ ścieków przemysłowych na fizyczne, chemiczne i mikrobiologiczne właściwości wody w strumieniach. Cel ten osiągnięto, pobierając próby wody do analiz z 8 odpływów, z 22 punktów kontrolnych i miejsc zrzutu. Wyniki charakteryzują odpływy i ich wpływ na wody odbiornika ścieków. Zrzuty ścieków powodowały znaczne zanieczyszczenie strumieni, ponieważ większość parametrów (pH, zawiesiny, mętność, BZT, ChZT, Mg, NO₃, Fe, Cu, Pb, Cr, suma bakterii heterotroficznych, bakterie grupy coli) przekraczała normy jakości wody pitnej ustalone przez WHO w 2011 r. Jedynie stężenie rozpuszczonego tlenu, Na, Zn, Ca i Na spełniały te normy. Obecność E. coli stwierdzano we wszystkich próbkach, duże były także wartości stężenia bakterii grupy coli. Zaleca się, aby zakłady przemysłowe poddawały ścieki oczyszczaniu przed ich zrzutem do strumieni.

Słowa kluczowe: jakość wody, ścieki przemysłowe, zanieczyszczenie strumieni, źródła wody pitnej