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PHARMACEUTICAL COMPOUNDS IN WASTEWATER DISCHARGED FROM A UNIVERSITY TEACHING HOSPITAL LIQUID WASTE TREATMENT PLANT

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ABSTRACT

Pharmaceutical compounds detected in wastewater discharged from hospitals have raised environmental concerns because of the health risks associated with their exposure to aquatic life and humans. Water samples collected from the Ahmadu Bello University, Zaria, Nigeria, wastewater treatment plant were extracted using the solid phase extraction method and analysed using the High Performance Liquid Chromatography (HPLC). In the wastewater matrices investigated, amoxicillin had the highest concentration of 8066 µg/L while ibuprofen had a concentration of 165.50 µg/L. Acetaminophen had the lowest concentration of 34.31 µg/L. This study showed that some pharmaceutical compounds were not effectively removed during the wastewater treatment.

Key words: Extraction, hospital, pharmaceuticals, treatment, wastewater

INTRODUCTION

Pharmaceuticals are detected constantly in aquatic environments including surface water, ground water and drinking water [1, 2]. This has raised environmental concerns because of the health risks associated with the exposure of aquatic life to them and the possible health risks to humans when they reach drinking water [3]. Environmental concerns were triggered when the occurrence of pharmaceuticals in river water was associated with feminization of fish living downstream of a wastewater treatment plant (WWTP) outfalls [4]. There is scanty information about the presence of pharmaceuticals in African water bodies although literature indicates that types of pharmaceuticals and their metabolites commonly detected are dependent on social, cultural, technological and agricultural factors [5, 6]; hence, it will vary for different geographical areas

and water bodies [3]. A study in Kenya reported the occurrence of ibuprofen, paracetamol, sulfamethoxazole and zidovudine at a high concentration (~ 10-30 μgL^{-1}) in the Nairobi River basin [7].

The pharmaceuticals which are often found in waste water are antibiotics, antacids, steroids, antidepressants, analgesics, anti-inflammatories, antipyretics, beta-blockers, lipid-lowering drugs, tranquillizers and stimulants [8]. Various studies have reported the presence of these pharmaceuticals in river water [9-11].

Hospitals are an important source of these compounds. A great variety of microcontaminants result from diagnostic, laboratory and research activities on one side and medicine excretion by patients on the other. These contaminants include active principles of drugs and their metabolites, chemicals, heavy metals, disinfectants and sterilizants, specific detergents for endoscopes and other instruments, radioactive markers and iodinated contrast media. Residues of pharmaceuticals can be found in WWTP effluents through disposal and inefficient removal by conventional systems [12-15].

Thus, this study is being carried out to identify and quantify some selected pharmaceutical compounds (acetaminophen, amoxicillin, and ibuprofen) in a hospital wastewater.

MATERIALS AND METHODS

Sample Collection and Preparation

Wastewater samples were collected from the Ahmadu Bello University Teaching Hospital wastewater treatment plant, Shika. A grab sampling technique was used to collect the samples from a depth of 1-2 cm from the water surface. Samples were collected in clean 2.5 L amber bottles. A 1 ml aliquot of 50% nitric acid was added to each of the samples to prevent microbial degradation of the samples. Samples were kept cool on ice during transportation to the laboratory and thereafter were kept in the refrigerator at 4 ^{o}C until extraction following the method described by Hischerova *et al* [16]. At each site, at least three samples were taken ($n \geq 3$) and all samples were extracted within a week of sample collection.

Solid Phase Extraction of the Samples

The samples were filtered using the Whatman filter paper (125 mm in diameter) and the target analytes were extracted using the methods reported by Matongo *et al* [3] after pH optimization in order to improve the recovery of target analyte. Oasis Hydrophobic-Lipophilic Balance (HLB)

Solid Phase Extraction (SPE) cartridges were used to achieve simultaneous extraction of the target analytes due to its versatility. The optimized extraction method that was used is briefly described as follows: The HLB was conditioned with 5 ml methanol and equilibrated with 5 ml of water and adjusted to a pH of 4.0 with 0.1M acetic acid. The sample (300 ml) was then loaded into the cartridge and the flow rate was maintained at 4 ml min^{-1}. The solid phase was subsequently dried at 25 °C for 30 minutes and analyte was eluted with 10 ml of methanol followed by 5 ml of acetone. The eluent was evaporated to dryness under vacuum and reconstituted with 1 ml of methanol.

High Performance Liquid Chromatography Determination of Selected Pharmaceutical Compounds

Standards of acetaminophen, ibuprofen, and amoxicillin were purchased from Sigma Aldrich (South Africa). All reagents used for HPLC analysis were of HPLC grade. Ultra-pure water using Elix Millipore water system was used in the preparation of all the standards. The determination of the selected pharmaceutical compounds was performed using the HPLC Merck Hitachi Elite LaChrom L-2200 Series. L1 (25 cm × 4 mm in diameter, 5 µm particle size) column was used for separation and quantification of the target analytes and the UV detector was used.

RESULTS AND DISCUSSION

The calibration data for the standards of selected pharmaceutical compounds that were studied are presented in Table 1. Acetaminophen had a retention time of 2.330 minutes, a limit of detection (LOD) of 4.2×10^{-6} µg/L, a limit of quantification (LOQ) of 1.3×10^{-5} µg/L and a correlation regression (R^2) of 1.000. Amoxicillin had a retention time of 1.543 minutes, an LOD of 2.1×10^{-3} µg/L, an LOQ of 6.4×10^{-3} µg/L and an R^2 value of 0.9939. Ibuprofen was observed to have a retention time of 3.827 minutes, an LOD of 4.1×10^{-3} µg/L, 1.3×10^{-2} µg/L and an R^2 value of 0.9770. Table 2 gives the concentration of the pharmaceutical compounds found in the hospital wastewater. Acetaminophen was found to have a concentration of 34.31 µg/L; amoxicillin had a concentration of 8066 µg/L and ibuprofen had a concentration of 165.50 µg/L.

Table 1: Calibration Data and Method Validation Parameters (HPLC)

Analyte	Therapeutic Class	R_t/min	µg/L LOD	µg/L LOQ	R^2
Acetaminophen	Antipyretic	2.330	4.2×10^{-6}	1.3×10^{-5}	1.0000
Amoxicillin	Antibiotic	1.543	2.1×10^{-3}	6.4×10^{-3}	0.9939
Ibuprofen	Antipyretic	3.827	4.1×10^{-3}	1.3×10^{-2}	0.9770

LOD-Limit of Detection; LOQ-Limit of Quantification

Table 2: Pharmaceutical Compounds in the Waste water

Analyte	Concentration (µg/L)
Acetaminophen	34.00±0.72
Amoxicillin	8066.00±48.10
Ibuprofen	165.50±2.12

Acetaminophen was found to have a concentration of 34.31µg/L in the hospital wastewater. This is higher than the concentration of 2.57 µg/L obtained by Olaitan *et al* [17] in irrigation wells in a pharmaceutical industrial area in Sango Ota, Ogun State, Nigeria. Amoxicillin had a concentration of 8066 µg/L. It was the most abundant pharmaceutical residue observed in this study and its high presence could be an evidence of the high dependence of the people in the locality on amoxicillin. This observation is in line with reports from literature that commonly detected pharmaceutical residues are dependent on social, cultural, technological and agricultural factors (5-6). Ibuprofen had a concentration of 165.50 µg/L which is higher than the value of 117 µg/L obtained by Matongo *et al* [3] in Msunduzi River, KwaZulu-Natal, South Africa.

Acetaminophen, amoxicillin and ibuprofen were identified because they were present in the hospital wastewater in their unmetabolized form. Most pharmaceutical compounds get transformed into other compound within the wastewater which makes it difficult to identify them as the original compounds.

CONCLUSION

The findings of this study show that pharmaceutical residues (acetaminophen, amoxicillin and ibuprofen) are present in hospital wastewater and this poses threat to the environment when the wastewater is eventually discharged. It is therefore imperative to ensure that treatment technologies capable of removing these residues be employed in the treatment of the wastewater.

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