



Original Research Article

Assessment of Microplastic Pollutants in Idah Local Government Area Along River Niger, Kogi State, Nigeria

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ARTICLE INFORMATION

Article history:

Received 17 Aug, 2019

Revised 05 Oct, 2019

Accepted 13 Oct, 2019

Available online 30 Dec, 2019

Keywords:

Fourier transform infrared

spectroscopy

Microplastic

River Niger

Pollutant

Stereomicroscope

ABSTRACT

This study was to investigate the concentration of microplastic pollutants in Idah local Government Area along River Niger in Kogi State, Nigeria. The water and sediment of River Niger was collected with a non-plastic equipment-container from Idah in Kogi state, using a random sampling method. The sediments sample was prepared in the laboratory by sanitizing, heating, sieving and filtering before it was examined by a stereomicroscope and Fourier Transform Infrared Spectroscopy (FTIR) for microplastic identification and analysis. The total of the microplastic discovered in the water by the FTIR and the stereomicroscope were 510,419 ppm and 455,600 ppm respectively. Also, the microplastic discovered in the sediment using FTIR and stereomicroscope were 496,281 ppm and 118,500 ppm respectively. The sum total of the microplastic discovered in both water and sediment were 1,047,200 ppm and 574,100 ppm respectively using Fourier transform infrared spectroscopy.

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1. INTRODUCTION

Microplastics are very small pieces of plastics that pollute the environment. Microplastics are not a specific kind of plastic, but rather any type of plastic fragment that is less than 5 mm in length according to the U.S. National Oceanic and Atmospheric Administration (NOAA) (Arthur et al., 2009; Collignon et al., 2014). They enter natural ecosystems from a variety of sources, including cosmetics, clothing, and industrial processes. A number of human activities potentially introduce microplastic into marine environment, and examples of such activities include the improper disposal of plastics and the international use of microscopic plastic particles for personal and industrial uses (e.g. polyester) shed during cloth washing (Browne et al., 2007; Cole et al., 2011). Plastic pollution is globally distributed across all oceans due to its properties of buoyancy and durability, and the sorption of toxicants to plastic while traveling through the environment have led some researchers to claim that synthetic polymers in the ocean should be regarded as hazardous waste (Mato et al., 2001; Teuten et al., 2007; Rochman et al., 2013). Several sources are

responsible for creating microplastic pollutant in River and these forces could be mechanical forces, sunlight, and water down and fracture, long plastic containers (Zeng et al., 2005).

The distribution of microplastics in the marine environment is strongly dependent on their density. The density of a virgin-polymer particle is often altered during the manufacturing process (e.g. density increase due to addition of inorganic fillers, density decrease due to foaming of the polymer) as well as through ageing or biofouling processes (Gregory 1983; Morét-Ferguson et al., 2010; Harrison et al., 2011). This research work is focused on the determination of the concentration of microplastic pollutants in River Niger around Idah in Kogi State and Agenebode in Edo State of Nigeria.

2. MATERIALS AND METHODS

2.1. Sample Collection

The sampling was done randomly along River Niger around Idah Local Government, Idah-Agenebode boundary. In this study, sampling specimens were defined as ‘Surface water sample and sediment sample’. Fourteen Idah water samples and 12 sediment samples were collected. On the basis of the control section settled by the environmental protection department of Idah local government, the representative points were selected as water sampling site and the sediment sampling site. The sampling sites in the River Niger were equally distributed. Both surface water and sediment samples collections cover the River bank and the centre of the River.

Surface water and sediment samples were collected using a previously reported method with some modifications. In the sampling of surface water, thirty liter surface water samples (0–30 cm in depth) was collected by a pre-cleaned large flow sampler. The collected water was filtered with a 45 µm stainless sieve. All of the solids on the sieve were rinsed carefully into a 1 L glass jar with deionized water while a 5 % formalin solution was selected as preservative. Three duplicate samples were collected at each sampling site. At each sampling interval, the sampler and stainless sieve were cleaned carefully with deionized water to reduce cross-contamination.

For the sediment sampling, the top sediment (0–2 cm) of the river line was collected with a stainless shovel. Sediment samples were collected five times at each sampling site, about 5 m away from each other, and then mixed together and covered with aluminum foil. A 0.3 m × 0.2 m quadrant was used to delineate the scope of the sediment collection. Approximately 1 kg sediment sample was collected at each sampling site.

Surface water and sediment samples were placed in sealed glass bottles and container then placed in a 5 °C sampling box to avoid shaking and contamination during transportation. The samples then were transported to the laboratory for analysis.

2.2. Sample Preparation

In order to eliminate the interference of organisms and sediments in the collected samples, the microplastics needed to be separated. Samples were pretreated using a method supported by the National Oceanic and Atmospheric Administration with some modifications. In treating the surface water samples, a hydrogen peroxide solution (30%, v/v) was used to remove visible organisms from the samples. Ferrous sulphate solution was used as catalyst to hasten up the removal of unwanted particles in the samples. Density separation was carried out using a zinc chloride solution (1.5 g/cm³) to remove sands and minerals from samples. A simple density separator is used in this study. An iron frame with an iron ring was placed on the laboratory bench, and a glass funnel was fitted with a latex tubing on the bottom of the stem for filtration support. A pinch clamp was settled to control the liquid flow from the glass funnel. The supernatants were

collected in the density separator and then filtered through 0.22 μm pore size of iron filter. Since natural air drying can curl the filter, all of the filters were dried in an oven set at 60 °C. Collected sediment samples were first treated by freeze-drying. The sediment (50 g) was transferred into a 1 L beaker, to which 400 mL of zinc chloride solution (1.5 g/cm³) was added with stirring. After stirring for 30 minutes, samples were allowed to settle for 24 hours in order to achieve density separation. Supernatants then were collected and treated with surface water treatment method described above. Microplastics were then filtered onto the filters in the same manner as the surface water samples.

2.3. Observation and Identification of Micro plastics using Stereomicroscope

All of the treated filters were placed in a pre-cleaned Petri dish for observation. The Petri dishes were placed under a stereomicroscope with a digital camera for examination. Suspected particles were identified according to their morphological characteristics. The identification was based on classification standards from previous studies (Blumenröder et al., 2017; Yu et al., 2017; Di and Wang, 2017).

2.4. Observation and Identification using Fourier Transform Infrared Spectroscopy

A Fourier Transform infrared spectroscopy (FT-IR) was used for further identification. The wavelength of incident laser was set to 532 nm and the FT-IR spectra were from 50 to 3500 cm⁻¹. The FT-IR images of the sample were analyzed to identify and quantify the plastic present. This analysis required removal of the materials other than the subject investigated. The sample preparation method was optimized for the different sample type (water and sediment) to achieve this.

2.5. Quality Assurance and Quality Control

A series of measures were adopted to avoid potential background contamination during sampling and laboratory processing. Researchers wore cotton lab coats and nitrile gloves during all of the processes. All of the containers and experimental instruments were pre-cleaned three times by ultrapure water and wrapped in aluminum foil when not in use. Ten blank tests using the methods described in sections 2.2 and 2.3 for determine the background values of contamination from the laboratory. Thirty liters distilled water was filtered onto a metal filter. These filters were kept in the lab for 72 hours without any cover. After 72 hours, these filters were observed by a stereomicroscope mentioned above. The results of blank tests shown that no microplastics were found in the filters. Absence of microplastic indicated that the background contamination in this study could be neglected.

3. RESULTS AND DISCUSSION

Observation of the spectral shows clearly that the majority of particles are of natural origin such cellulose and protein. In particular, the fibrous particles can be seen and are of cellulosic origin observed with stereomicroscope.

The level of microplastics in Table 1 shows cellulose to be highest followed by polyester on the FTIR analysis while protein tends to be higher in the observation with stereomicroscopic followed by cellulose acetate. On the overall, more microplastics were recorded with the FTIR analysis than stereomicroscope in the sediments.

In Table 2 similar trend as in Table 1 was observed with cellulose having the highest concentration in ppm followed by polyester which makes it different slightly using the FTIR analysis, while in stereomicroscope, the cellulose also retained the highest count followed by polyester. This indicate more polyester in water sample than in sediments when compared to Table 1.

The number of particles present in an aquatic environment could potentially play a significant role in the impacts of microplastic on the aquatic Fauna (Vollertsen and Hansen, 2016). In this study, the quantification of plastic was done by determining the number of plastic particles. Attention was paid to the sample preparation method as there is potential, to increase the quantity of particles by breaking larger particles into smaller particles. Based on the Fourier transform infrared spectroscopy and Stereomicroscope analysis, the study shows that sediment and soil sample have a risk of underestimating the amount plastic. The water samples in this study had the highest concentration of plastic, with the prepared samples visibly containing plastic particles. The presence of particles similar in shape to the polystyrene particles may have complicated the count of the recovered polystyrene. Currently, the reliability and comparability of data on marine microplastic concentrations is hampered by the huge variety of different methodologies applied, which lead to the generation of data of extremely different quality (Hidalgo-Ruz et al., 2012).

Table 1: Analysis of microplastic in one kg of sediment

S/N	Particle identified	Concentration (ppm) using FTIR	No. of particle count (ppm) using stereomicroscope
1	Polyethylene	48	500
2	Polypropylene	1498	5000
3	Polyester	15400	1600
4	Polyamide	1500	3400
5	Polyvinyl chloride	700	1100
6	Polyurethane	600	7400
7	Polystyrene	250	500
8	Epoxy	100	1200
9	Polyoxymethylene	45	500
10	Cellulose Acetate	700	1100
11	Protein	9400	52700
12	Cellulose	464840	40200
13	PU paint	500	1100
14	Alkyd	700	2200
Total		496,281	118,500

Table 2: Analysis of microplastic in one litre of water

S/N	Particle identified	Concentration (ppm) using FTIR	No. of particle count (ppm) using stereomicroscope
1	Polyethylene	52	600
2	Polypropylene	1502	5300
3	Polyester	15700	16200
4	Polyamide	1700	3500
5	Polyvinyl chloride	800	1200
6	Polyurethane	6100	7500
7	Polystyrene	250	600
8	Epoxy	100	1100
9	Polyoxymethylene	55	600
10	Cellulose Acetate	800	1200
11	Protein	9600	3500
12	Cellulose	472460	410900
13	PU paint	500	1200
14	Alkyd	800	2200
Total		510,419	455,600

Table 3: Sum of the amount of microplastic identified in both water and sediment

S/N	Particle identified	w/w Concentration (ppm) using FTIR	No. of particle count (ppm) using stereomicroscope
1	Polyethylene	100	1100
2	Polypropylene	3000	10300
3	Polyester	31100	17800
4	Polyamide	3200	6900
5	Polyvinyl chloride	1500	2300
6	Polyurethane	6700	14900
7	Polystyrene	500	1100
8	Epoxy	200	2300
9	Polyoxymethylene	100	1100
10	Cellulose Acetate	1500	2300
11	Protein	91000	56200
12	Cellulose	907300	451100
13	PU paint	1000	2300
14	Alkyd	1500	4400
Total		1,047,200	574,100

4. CONCLUSION

The level of microplastic analyzed from the water was higher than the sediment using both method of analysis this probably indicate that microplastic pollutant basically float on water unlike heavy metal that settle down in the sediments. The level of microplastic pollutant analyzed indicate the degradation of plastics into different components which are not further degradable, also some these particles like cellulose and protein are from natural source. Presently, there is no concrete standard to the level toxicity or permissible limit of microplastic in both man and other animals, but its potential environmental risk and health effects cannot be over looked.

5. ACKNOWLEDGMENT

Our gratitude goes to the technical staff of the Department of Pure and Industrial Chemistry, Kogi State University, Anyigba for their support.

6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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