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Management consequences and diseases transmission potentials of dredge sediments from Nworie River, Owerri, Eastern Nigeria

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Abstract

Improper disposal of Nworie River dredge sediments can serve as source of pathogenic organisms to the inhabitants of Owerri, eastern Nigeria. This study aimed at determining the bacterial quality of the sediments to help ascertain its diseases transmission potentials to the environment. Five grams of 20 sediment samples (10 at each side and each about 400m apart, along the River bank) were collected and subjected to standard physical treatment and microbiological analysis. The Total Heterotrophic Bacterial Count (THBC) ranged from 6.9 x 10^5 to 3.2 x 10^3 cfu/ml while the Total Coliform Bacterial Count (TCBC) ranged from 6.3 x 10^3 to 2.8 x 10^2 cfu/ml. The following organisms were isolated from all the sediment samples: *Escherichia coli*, *Klebsiella mobilis*, *Shigella dysenteriae*, *Salmonella typhi*, *Proteus vulgaris*, *Enterobacter cloacae*, and *Citrobacter freundii*. The high THBC may be an indicator of poor general biological quality of the dredge sediments or spoils. The TCBC is a reliable indication of the possible presence of fecal contamination and is consequently, correlated with pathogens in the dredge spoils. Some of the isolates are responsible for diarrheal, typhoid and gastroenteritis, bacillary dysentery, colonization of the intestinal, urinary, or respiratory tract to fatal septicemia, and meningitis with high morbidity and mortality potentials. Proper disposal of dredge sediments and inclusion of the determination of potential pathogens in its management will assist in controlling environmental consequences of dredging.

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Introduction

Dredging activities in fresh water systems have negative environmental consequences resulting from generation of streambed sediments or dredge spoils and the implication of its subsequent proper disposal to avoid transmission of diseases agents. Streambed sediment has been increasingly attracting attention as a reservoir of pathogenic bacteria. Dredged spoils microorganisms can be released to water in substantial amounts as sediments re-suspend (Byappanahalli *et al*., 2003; Muirhead *et al*., 2004; Giddings and Oblinger, 2004; Cinotto, 2005). Dredged spoil provides a favorable chemical and biological environment for bacteria (Gannon *et al*., 1983), and can protect bacteria from protozoan predators (Davies *et al*., 1995).

Management of contaminated dredged spoil has focused predominantly on chemicals, whereas potential risks posed by pathogenic biological contaminants are assessed on an ad hoc basis. Currently the Inland Testing Manual (U.S. Environmental Protection Agency (USEPA), 1998) addresses pathogenic concerns about sediments as they relate to Clean Water certification requirements. The three major areas of concern identified for microbiological contamination and effects related to dredged spoils are (1) contamination of harvestable fish, (2) body contact through recreational use, and (3) contamination of drinking water.

Sediments extend survival of pathogens and pathogen indicators because they provide nutrients as well as protection from predation. Due to the accumulation of pathogens in bottom sediments, re-suspension of sediments can result in desorption of pathogens from sediments and the subsequent contamination of the overlying surface waters. Activities that re-suspend sediments such as storm water events, wave action, tides, recreational use, and dredging can lead to transient increases in pathogens and pathogen indicators in the water column (Grimes, 1975, 1980; Kebabijian, 1994).

Nworie River serves as source of water for domestic, recreational, and industrial activities for about 2million inhabitants of Owerri and has been subjected to dredging and the dredge sediments or spoils dumped and exposed by the River banks. As these sediments are exposed they can serve as source of contamination of air, water, including recontamination of the River, and food, and infection of people who swim in the River. The microbial diseases transmission potentials of the spoils to the inhabitants and users can not be ascertained without proper assessment of microbial pathogens. Therefore this research was targeted at determining the population and load of bacterial pathogens in the sediments to help understand the risk associated with the improper disposal of the dredge sediments.

Materials and methods

Study area

The study area is as shown in Fig. 1. Nworie River is a major River that cuts across the Owerri Metropolis, Eastern Nigeria and provides water for domestic, recreational, and industrial activities for about 2million inhabitants of Owerri. It serves as a recipient of waste water and solid waste from hospitals, industries, commercial and domestic activities. Recently, dredging activities started at the River by the government where dredge sediments or spoils were dug out and disposed of along both sides of the River banks.

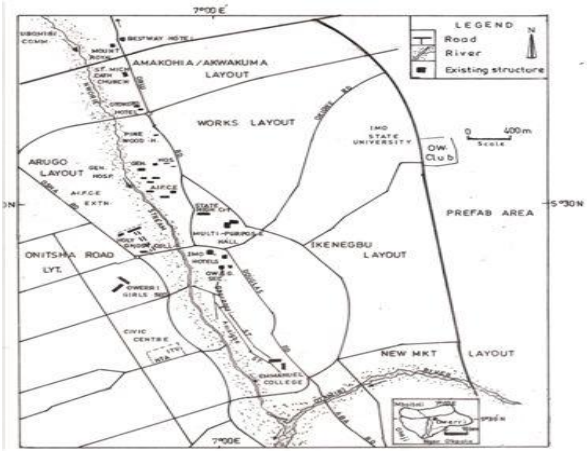

Fig. 1. Map of Owerri township showing the Nworie stream.

Sample collection and preparation

Five grams of 20 sediment samples (10 at each side of the River bank, 400m apart) were collected with sterile sediment samplers. Each 5g-sediment was put into a 25cm^3 conical flask and 20cm^3 sterile distilled water added to produce a suspension (USEPA, 1998). Sonication process as described by McDaniel and Capone (1985) was used to elute into suspension the bacterial fraction attached to the sediment. Following dispersion, the water phase was separated from the sediment by settling and/or gentle centrifugation. Once elutriate was prepared, it was used immediately for microbiological analysis.

Microbiological analysis

Sterilization of media was carried out by moist heat sterilization method using autoclave at 121^{o}C, 15psi and for 15 minutes. Heat stable materials were sterilized using hot air oven at 160^{o}C for 1 hour as described by Cruickshank *et al.* (1982). Heat labile materials were aseptically rinsed with alcohol and distilled water. The elutriates were aseptically subjected to 10 fold serial dilutions to dilute the population of microorganism sufficiently in sterile blanks of 9ml peptone water and then plated to produce discrete colonies for easy enumeration. The media used include Nutrient agar, MacConkey agar, Eosin Methylene Blue agar, TCBS, and *Salmonella – Shigella* agar. All media were prepared as directed by the manufacturer. The method of Dubey and Maheshwari (2004) was adopted for the inoculation of media. Spread plates of appropriately diluted samples were incubated at 37^{o}C for 24 hours for Heterotrophic Bacterial Count (HBC) while Coliform Bacterial Count (CBC) was determined after incubation at 45^{o}C for 24 hours in MacConkey agar. Identification of isolates was based on the scheme described by Cheesborough (1984).

Results

The Total Heterotrophic Bacterial Count (THBC) and the Total Coliform Bacterial Count (TCBC) is as shown in Table 1. The Total Heterotrophic Bacterial Count (THBC) ranged from 6.9 x 10^5 to 3.2 x 10^3 cfu/ml while the Total Coliform Bacterial Count (TCBC) ranged from 6.3 x 10^3 to 2.8 x 10^2 cfu/ml. The following organisms were isolated as shown in Table 2 from all the sediment samples: *Escherichia coli*, *Klebsiella mobilis*, *Shigella dysenteriae*, *Salmonella typhi*, *Proteus vulgaris*, *Enterobacter cloacae*, and *Citrobacter freundii*. These organisms are of public health importance. Members of the family Enterobacteriaceae include *Escherichia coli*, *Klebsiella mobilis*, *Shigella dysenteriae*, *Salmonella typhi*, *Proteus vulgaris*, *Enterobacter cloacae*, and *Citrobacter freundii*.

Table 1. Bacterial counts (cfu/ml) of samples of Nworie River sediments.

Samples	THBC	TCBC
A	5.8 x 10^4	3.2 x 10^2
B	7.2 x 10^4	4.8 x 10^2
C	6.9 x 10^5	5.1 x 10^3
D	4.4 x 10^4	3.8 x 10^2
E	3.2 x 10^3	2.8 x 10^2
F	6.7 x 10^4	4.6 x 10^2
G	5.1 x 10^4	4.4 x 10^3
H	3.7 x 10^3	6.3 x 10^3
I	9.1 x 10^4	2.8 x 10^3
J	7.6 x 10^3	5.2 x 10^2

A – J = Samples

Discussion

The Total Heterotrophic Bacteria Count (THBC) test also called "total count" "plate count" is assured to provide an estimate of the total number of bacteria in a sediment sample that will develop into colonies during a period of incubation in a nutrient. This test detects a wide array of bacteria including pathogens, and opportunistic pathogens, but it does the pretend to report all of the bacteria. This is in accordance with the works of Ihejirika *et al.* (2011). According to USEPA (2003), high THBC may be an indicator of poor general biological quality of dredge sediments or spoils. The coliform test is a reliable indication of the possible presence of fecal contamination and is consequently, correlated with pathogens in the dredge spoils (Dreeszen, 1996).

In general, it appears that cooler freshwater environments like the river banks, devoid of sunlight

prolong survival of pathogens and their indicators. In addition, sediments have been shown to greatly extend the survival of pathogens (Davies *et al.* 1995; Sherer *et al.* 1992). Once pathogens enter the water column, they may become associated with various suspended solids that eventually settle out and accumulate in the underlying sediments. Both bacteria and viruses possess electrostatic charges, which facilitates their adsorption onto fine-grained high-organic charged clays and mud. Sediments can contain 100 to 1000 times as many pathogen indicators as the overlying water (Grimes 1975, 1980).

As *Escherichia coli* was isolated from the dredge spoils, it indicated recent fecal contamination of the different sources. This result is supported by the works of Health Canada (2006), Cabral (2010) and Ihejirika *et al.* (2011). While most strains of *E. coli* are non-pathogenic, some can cause serious diarrheal infections in human (Health Canada, 2006).

The presence of *Salmonella typhi* in the dredge sediments might be due to contamination from domestic sewage, agricultural waste and storm water runoffs. This argument is supported by the reports of WHO (2008) and Arvanitidov *et al.* (2005). According to Le Minor (2003), *Salmonella typhi* is responsible for salmonellosis, especially typhoid and gastroenteritis. This implies that controlled sewage water systems and personal hygiene will reduce the incidence of gastroenteritis and typhoid fever (Popoff *et al.*, 2005) that might result from contamination from the dredge sediment.

The presence of *Shigella dysenteriae* in all the samples might be due to unsanitary condition of the environment and secondary fecal contamination from intermediary sources that entered the River (Ihejirika *et al.,* 2011). The implication of this is the risk of possible outbreak of shigellosis or bacillary dysentery when drinking water and food stuff and food are contaminated with the dredge sediments. This was in agreement with the report of Emch *et al.* (2008).

Proteus vulgaris is an enteric pathogen associated with the feces of animals including humans (Ihejirika *et al.,* 2011) and a wide variety occurs in manure, soil, and polluted waters. It has been associated with enteric diseases.

Klebsiella mobilis are ubiquitous in the environment (Cabral, 2010). *Klebsiella mobilis* has been associated with contaminants like wastewaters, plant products, fresh vegetables, food with a high content of sugars and acids, frozen orange juice concentrate, sugarcane waste and living trees. *Klebsiella mobilis* can cause human diseases, ranging from asymptomatic colonization of the intestinal, urinary, or respiratory tract to fatal septicemia (Grimont *et al.,* 2005).

Enterobacter cloacae might be an implication of fecal contamination of Nworie River. This was supported by the works of Grimont and Grimont (2005). Apart from fecal contamination, *Enterobacter cloacae* might have been introduced from other sources like soil, polluted water, and dead plants materials (Ihejirika *et al.,* 2011). The presence of *Enterobacter cloacae* in dredge spoils implied possible risk of nosocomial and health care-associated infection. This argument is supported by the reports of Hirdron *et al.* (2008) and Ihejirika *et al.* (2011).

Citrobacter freundii (14.3%), is included in a number of pathogenic bacteria capable of causing serious disease and being discharged into rivers (Donovan *et al.,*2008), Nworie River inclusive; has ability to produce an enterotoxin and this become an intestinal pathogen in environments such as water, sewage, soil and food (Frederisksen and Sogaard, 2003). The presence of *Citrobacter freundii* is significant because it can cause meningitis with high morbidity and mortality potentials. This is in accordance with the report of Donovan *et al.* (2008).

Table 2. Morphological and Results Of Biochemical Analysis of Bacteria Isolates.Table 2. Morphological and Results Of Biochemical Analysis of Bacteria Isolates.

	GROWTH MORPHOLOGY	BIOCHEMICAL														
		Gram reaction	Motility	Gelatin Hydrolysis	Oxidase	Citrate	Indole	Urease	H_2S	VP	MR	Glucose	Maltose	Manitol	Lactose	Probable Isolate
1	Round opaque smooth flat entire creamy rods	-ve	+	-	-	-	+	-	-	-	+	+	+	+	+	*Escherichia coli*
2	Milkish coloured, round edge convex rods	-ve	+	+	-	-	-	-	+	-	+	+	+	+	+	*Salmonella typhi*
3	Smooth colourless circular rods, which is opaque with the entire margin	-ve	+	-	-	-	+	-	-	-	+	-	-	+	-	*Shigella dysenteriae*
4	Translucent rods, milkfish, has fishy smell and swarming appearance	-ve	-	-	-	+	-	+	+	-	+	-	-	-	-	*Proteus vulgaris*
5	Whitish shiny convex rods, mucoid with entire margin.	-ve	-	-	-	+	-	+	-	+	-	+	+	+	+	*Klebsiella mobilis*
6	Milky shiny, convex smooth rods, with entire edges	-ve	+	-	-	+	-	+	-	+	-	+	+	+	-	*Enterobacter cloacae*
7	Round opaque smooth flat entire creamy rods	-ve	-	-	-	+	-	-	+	+	-	+	+	+	-	*Citrobacter freundii*

Key + = Positive - = Negative

Conclusion

This work confirmed the presence of pathogenic organisms in the exposed dredge sediments of Nworie River and implied that adequate measures should be taken to properly dispose of the dredge sediments to avoid colossal health consequences of dumping of the dredge spoils on the crowded inhabitants of Owerri Metropolis.

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