World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 5.088

EVALUATION OF ENVIRONMENTAL HEALTH STATUS OF EDONWHII SANDY BEACH IN AKWA IBOM STATE USING BIO-PHYSICOCHEMICAL INDICES OF CONTAMINATION

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Article Received on 26/06/2018 **Article Revised on 16/07/2018** **Article Accepted on 06/08/2018**

ABSTRACT

The environmental health status of Edonwhii sandy beach was investigated using standard health/microbiological protocols and analytical procedures. The result revealed diverse microbial groupings in the study area which include the following bacteria; total heterotrophic bacteria (THB) with mean counts of $6.8\pm0.5x10^4$ $cfug^{-1}$, *Staphylococcus aureus* having counts of $1.3\pm1.7x10^4$ $cfug^{-1}$, *Vibrio* sp. with counts of $4.3\pm2.0x10^4$ $cfug^{-1}$, total and faecal coliforms, Clostridia and other members of the Enterobacteriacaea. The results also reveal the occurrence of dermatophytic fungi with an average population of $2.9 \pm1.5 \times 10^2$ cfug $^{-1}$ with other hyphomycetous fungi such as *Aspergillus* sp, *Penicillium* sp. *Rhizopus* sp and *Mucor*. While most of these organisms showed 100% prevalence in sand, however, they exhibited low to moderate prevalence in the water. Also encountered were ova of *Necator americana, Ascaris lumbricoides* and other helminthes that could serve as microbiological quality indicators of the sandy beach environment. Physicochemical results indicate low levels of Total Organic Carbon (TOC), Total Nitrogen (TON) and available phosphorus (1.8%, 0.25% and 1.69mg/kg respectively) in the sand which also showed deficiencies of Ca^{2+} (6.97mg/kg), Mg^{2+} (2.89mg/kg), Na^+ (7.69mg/kg) and K^+ (0.16mg/kg), and total recoverable hydrocarbons ranged between 9.38mg/kg and 10.44mg/kg. The levels of these parameters influenced the beach sand fertility and may be responsible for the low microbial populations observed. However, based on the microbiological indices, the potential health risk associated with exposure to contaminated beach sand and water at Edonwhii is high especially for the most vulnerable populations. This study therefore provides a useful baseline assessment of sandy beach microbiological flora and can serve as reminder of the occurrence of potentially harmful fungi, bacteria and helminths in our local beaches. To improve the recreational qualities of these beaches, qualitative/quantitative criteria or threshold standards should be set, periodic monitoring and beach cleaning need to be performed.

KEYWORDS: Bio-physicochemical, Contamination, Coliforms, Hydrocarbonoclastic bacteria and Hydrocarbons.

1.0 INTRODUCTION

Beaches represent the unconsolidated sediment that lies at the junction between water (such as oceans, seas, lakes and rivers) and land and usually composed of sand, mud or pebbles (Zaleha *et al.,* 2011). These are landforms along the shoreline of an ocean, seas, lakes or rivers consisting of loose particles which are made of rock, such as sand, gravel shingles, pebbles or coral line algae. They are often regarded as biological deserts, mainly in contrast with rocky shores (Herrier *et al*., 2005). Yet, while they do not exhibit the same level of biodiversity as their hard substrate counterparts, sandy beaches possess a clear functional role. Sandy beaches make up two-third of the world's ice-free coastline and serve as buffer zones or shock absorbers that protect the coastline, sea cliffs or dunes from direct wave attack (Defeo *et al*., 2009). It is an extremely dynamic environment where sand and water are always in motion.

The stretch of the Atlantic coastline of the Gulf of Guinea bothering southern Nigeria is replete with beaches which typically occur in areas along the coast where wave or current action deposits and reworks sand sediments. Amongst the popular beaches in Nigeria include the Calabar beach in Cross River, The Bar beach in Victoria Island Lagos, the Lekki beach at the Lekki Peninsula in Lagos, Amadi beach in Port Harcourt, Uta Ewa and Ibeno beaches in Ikot Abasi and Ibeno LGAs of Akwa Ibom State. Except for Lekki beach, most of the beaches listed above exist as "wild beaches" because they do not have lifeguards or trappings of modernity,

essentially lacking basic amenities. These beaches are called undeclared, undeveloped or undiscovered beaches.

Tourism and recreational activities have been known to represent disturbances and been linked to pollution and industrialization that may affect spatial heterogeneity, structure and dynamics of natural community (Zaleha *et al.,* 2011). The impacts caused directly by recreational activities are becoming important environmental issues. Human encroachments are putting a strain on coastal environments and natural splendour. Over the past decade, there has been significant increase in the number of beach goers. This has resulted in simultaneous build-up of anthropogenic presence along the coasts. Maintaining the integrity of these areas for public is of utmost importance for the economic viability of coastal communities (Sabin *et al.*, 2014). Beaches are experiencing unprecedented natural and human perturbation on the landward side by coastal development and on the ocean side by sea level rise and coastal erosion. Beach ecosystems are affected by many different types of human pressures, from recreation to pollution. The major sources of pollutants in the beaches are: oil (petroleum and products) from offshore drilling accidents and leaks, ocean tanker wrecks, seepage and leaching from factories and plants, cooking oils and grease poured down the sink drains in homes.

To date, most tourism impact studies have been mainly focused on changes in abundance and diversity of large macro-benthos, loss of individual species or decreasing populations of birds whereas smaller life forms including micro-organisms are highly neglected. Microorganisms are a significant component of beach sand. Bacteria, fungi, parasites and viruses have all been isolated from beach sand. A number of genera and species that may be encountered through contact with sand are potential pathogens. Accordingly, concern has been expressed that beach sand or similar materials may act as reservoir or vectors of infection (Roses *et al.,* 1988), although transmission by this route has not been demonstrated in epidemiological studies.

Recreational activities which involves contact with water and sand has grown world over, exposures to pathogens in recreational beach environments may result in disease. susceptible populations including people with reduced immune function e.g resulting from disease (cancer, human immunodeficiency virus (HIV), genetic susceptibility, or lack of acquired immunity to locally endemic disease may be at higher risk of contracting severe illnesses. Many infections occur on a seasonal basis and therefore beach users will be exposed to different and unfamiliar pathogens in beach water and sand in different locations and at different times. The World Health Organization (WHO) has been actively involved in the protection of human health from the use of recreational waters since the 1970s.

Researchers in America and Europe over the years have reported evidence from outbreak of disease associated to poor quality of recreational water. There are many unanswered question regarding the severity and frequency of illness associated with recreational water use. It is plausible that more serious illness could result for the recreational use of water and this association has not yet been investigated to any great extent. Despite the acknowledged constraints considerable information has become available to recreational water users in recent years concerning the microbial quality of the water they are using for recreation. However, the situation is different in Nigeria as no standards or guideline values for microbiological and chemical quality are available for her beaches. State costal managers have not recognize that beaches have value and have also failed to investigate health risk associated with beach activities in Nigeria.

The Niger Delta of Nigeria is a unique environment which confines one of the worlds' largest equatorial rainforests with its major estuarine systems emptying into the Atlantic Ocean. The region borders one of the longest coastlines extending from Lagos to Calabar and characterized by several beaches. It constitutes the hub of petroleum activity in Nigeria as it is the main petroleum bearing belt in the country. Thus, the region demands special attention for the conservation of its biological diversity and management of its natural resources including the beaches which have considerable potential for tourism and are witnessing unprecedented human patronage.

However, the sector is suffering increasing negative effects of unregulated urban growth and lack of adequate infrastructure. There are currently no national or international standards or guideline values for microbiological and chemical quality of beach water and sand. State Coastal Managers have not recognize that beaches have value and are natural ecosystems full of life, and have also failed to correlate human health risk with beach activities. The present study is therefore intended to provide information regarding the health hazards and risks associated with the recreational use of coastal environment of beach sand, exposure to algae and their products, exposure to chemicals and physical agents and pathogenic microorganisms. The information may be used as the basis for the development of national and, by extension, international approaches (including standards and regulations) to controlling the health risks, from hazards that may be encountered in recreational water environments.

2.0 MATERIALS AND METHODS

2.1 Samples Collection

Four sampling stations (BS1 – BS4) of 20 meters apart were demarcated. At each station, three sets of samples (sand and water) were collected from different locations, giving a total of 12 each of water and soil samples. Human and dog fecal matters were also collected at

different locations. Representative soil and water samples were obtained with the aid of soil Auger and Sterile 1 – litre plastic bottles respectively. The soil samples were generally taken from 0 – 10 cm depths from all the sample locations and contained in sterile polyethylene, while the faecal matters were collected with the aid of a hand trowel and were stored in sterile glass bottles. On the other hand, water samples were obtained from the low tide level at the swimming or surfing zone with the aid of Sterile 1 – litre plastic bottles. All the samples were stored in ice-pack coolers and immediately transported to the laboratories for analyses.

2.2 Microbiological Analysis

2.2.1 Treatment of Microbiological Samples

The soil and water samples were subsequently triturated and homogenized. To evaluate the microbial population, the samples were placed in contact with 0.35% NaCl solution (physiological saline) and shaken vigorously for 30 minutes, to release or extract the protists present in the samples. The soil-water matter suspensions and water samples obtained were serially diluted before used in the estimation of microbial densities.

2.2.2 Serial Dilution

Serial dilution of the samples was done according to the method of Collins and Lynes (1976). Precisely 10g of sand or faecal matter was measured and was introduced into a beaker containing 90ml of sterile distilled water. This was shaken for even distribution and thereafter 1ml of the aliquot was aseptically transferred into sterile test tubes containing 9ml of diluents to give a dilution of 10^{-1} . This was repeated until a ten-fold serial dilution level was attained. Similarly, 10ml of the water sample was introduced into 90ml of distilled water well shaken for even distribution and serially diluted.

2.2.3 Estimation of Microbial Loads Soil and Water Samples Collected from the Beach Environment

After serial dilution process, 1ml of the desired dilution factors, 10^{-4} and 10^{-2} for sand/faecal matter and water respectively was seeded or spread plated using a hooking stick on sterile petri dishes containing the appropriate media. The total heterotrophic bacteria and fungi were determined by the pour plate and surface-spread methods respectively (Harrigan and McCance 1990) using Bacto-nutrient agar and Sabouraud dextrose agar. The total coliform and faecal coliform bacteria were enumerated on MacConkey agar and Eosin and Methylene Blue (EMB) agar respectively. Using the same method, the *Salmonella* and *Shigella* count, *Vibrio* count, *Staphylococcus aureus, Clostriduim* and dermatophytic pathogens were enumerated using Salmonella- Shigella agar Thiosulphate – Citrate – Bile salts – Sucrose agar (TCBS), Staphylococcus medium No. 110, Renforced Clostridial agar and Dermatophytic test medium respectively, while oil agar was used for the estimation of counts of hydrocarbon utilizing bacteria and fungi.

For selective bacterial growth, Cycloheximide (100µg/ml) and benomyl (50mg/ml) were incorporated in Bact-nutrient agar and oil agar to eliminate fungal growth, while Streptomycin (0.5µg/ml) supplemented medium was used for the selective enumeration and isolation of fungi. The bacterial plates were incubated at 37^{o}C in a Gallenkamp incubator for 24 hours and fungal plates at room temperature (28 ± 2 ^{o}C) for 4 days, while the plates for hydrocarbon utilizing microorganisms were incubated at (28 ± 2 ^{o}C) for 7 days. Discrete colonies that appeared on the culture plates were enumerated with the aid of a Quebic Colony Counter and recorded as colony forming units (cfu per gram or milliliter of the soil or water samples respectively.

2.5 Characterization and identification of microbial isolates

The pure colonies obtained from the samples were characterized using standard procedure as described by *Bergey's Manual of Determinative Bacteriology* (1994. The colonies were subjected to Gram's stain and various biochemical tests such as motility test, catalase test, urease test, coagulase test, citrate test, hydrogen sulphide test, sugars utilization test and MR-VP test. Fungal isolates were identified according to the method Barnett and Hunter (1987).

2.6 Evaluation of Prevalence of Parasites Ova and Cysts in the Beach Environment

Precisely 3g of fresh faecal samples encountered in the beach site were separately collected into sample bottles with the aid of a spatula. The freshly collected faecal samples were transported to the laboratory where they were analysed for parasite ova and cysts. The formol-ether sedimentation concentration techniques were used for the analysis of the faecal samples for parasite eggs and cysts (Cheesbrough, 2005). Where immediate examination of faecal samples was not possible the collected samples were preserved in 4% formalin. The isolates were diagnosed based on the characteristics of the helminth ova and cysts with a compound microscope using x10 and x 40 objectives as recommended by Cheesbrough (2005). Reference was also made to taxonomic key of Soulsby (1982).

2.7 Physicochemical Analysis of Beach Sand and Water Samples

The physicochemical properties of the beach sand and water samples were analysed using standard analytical procedures recommended by APHA (1992 and 1998).

2.8 Statistical Analysis

Simple percentage was used to express the frequency of occurrence of microbial isolates where necessary

3.0 RESULTS

3.1 Microbiological Properties of the Beach Environment

(a) Microbiological Loads of the Beach Water and Sand Samples

Results of the microbial burden of the water and sand from the Edonwhii sandy beach are presented in Tables 1 and 2. The microbial groups detected include heterotrophic bacteria, coliforms and fecal coliforms, Salmonellae, Shigellae, *Vibrio* sp, *Staphyloccus aureus*, hydrocarbon utilizing bacteria, fungi and dermatophytic fungi. For the water sample (Table 1), ranges of $6.0x10^3$ – $3.4x10^4$cfuml^{-1} and $3.5x10^3$ – $6.1x10^3$ cfuml^{-1} were recorded for heterotrophic and coliform bacterial counts respectively. The *Vibrio* counts ranged between $1.4x10^1$cfuml^{-1} and $2.3x10^2$ cfuml^{-1}. On the other hand, values ranging from $1.2x10^2$ cfuml^{-1} to $1.3x10^2$cfuml^{-1}, $4.1x10^1$cfuml^{-1} to $5.3x10^2$ cfuml^{-1} and $1.9x10^2$cfuml^{-1} to $4.1x10^2$cfuml^{-1} were recorded for the densities of faecal coliforms, *Salmonella-Shigella* and *Staph. aureus* encountered in the beach water samples analyzed. The densities of hydrocarbon-utilising bacteria in water samples were low with a range of $2.2x10^1$ cfuml^{-1}to $2.4x10^2$ cfuml^{-1}.

Table 2 shows the densities of the different microbial groups encountered in the beach sand samples. Ranges of $6.3x10^4$ cfug^{-1} to $7.3x10^4$ cfug^{-1}, $4.3x10^3$ cfug^{-1}to $6.3x10^3$ cfug^{-1} and $4.3x10^3$ cfug^{-1} to $6.3x10^2$ cfug^{-1}were recorded for heterotrophic bacteria, coliforms and faecal coliforms respectively. On the other hand, densities ranging from $3.2x10^2$cfug^{-1}to$5.3x10^2$ cfug^{-1}, $1.2x10^2$cfug^{-1} to $6.2x10^2$cfug^{-1}, and 3.2x101cfug^{-1}to $6.2x10^1$cfug^{-1} and $2.6x10^3$cfug^1 to $4.2x10^3$cfug^1 were recorded for *Salmonella* sp, *Shigella* sp, *Vibrio* sp., *Clostridium* and *Staphylococcus aureus* respectively. The densities of hydrocarbon utilizing bacteria was higher in sand samples compared to water samples with a range of $2.3x10^2$ cfug^{-1}to $4.3x10^2$cfug^{-1}.

Data presented in Table 3 is the estimated bacterial pollution indices of the beach environment. The values of the TC/FC ratio recorded revealed an environment contaminated with faecal matter.

Table 1: Microbial loads of water samples from Edonwhii sandy beach.

Microbial groups	BWS 1 cfu/ml	BWS 2 cfu/ml	BWS 3 cfu/ml	BWS 4 cfu/ml	Mean ± SD cfu/ml	Recommeded Limits
Total Heterotrohic Bacteria	3.4×10^4	6.0×10^3	6.2×10^4	5.8×10^3	$2.7 \times 10^4 \pm 2.3$	-
Coliform count	6.1×10^3	5.2×10^3	4.7×10^3	3.5×10^3	$4.9 \times 10^3 \pm 0.9$	400
Faecal coliform count	1.2×10^2	1.3×10^2	-	-	$0.6 \times 10^2 \pm 0.5$	235
Salmonella-Shigella count	5.3×10^2	5.1×10^2	-	4.1×10^1	$2.7 \times 10^2 \pm 1.6$	-
Vibrio count	2.3×10^2	1.4×10^1	1.9×10^1	-	$6.5 \times 10^1 \pm 4.0$	-
Staphylococcus aureus count	2.3×10^2	4.1×10^2	3.2×10^2	1.9×10^2	$2.9 \times 10^2 \pm 0.9$	-
Hydrocarbon utilizing bacteria count	2.2×10^1	2.3×10^2	2.4×10^2	1.9×10^2	$1.7 \times 10^2 \pm 0.5$	50
Fungal count	5.1×10^3	5.5×10^4	5.3×10^3	5.0×10^3	$1.7 \times 10^2 \pm 3.5$	-
Dermatophytic fungal count	1.1×10^2	-	2.4×10^2	3.1×10^2	$1.65 \times 10^2 \pm 0.8$	-

Key: BWS 1 - Beach water station 1, BWS 2 - Beach water station 2, BWS 3 - Beach water station 3, BWS 4 - Beach water station 4.

Table 2: Microbial loads of sand samples from Edonwhii sandy beach.

Microbial groups	BSS 1 cfu/g	BSS 2 cfu/g	BSS 3 cfu/g	BSS4 cfu/g	Mean ± SD	Recommened Limits
Total Heterotrohic Bacteria	6.3×10^4	6.4×10^4	7.2×10^4	7.3×10^4	$6.8 \times 10^4 \pm 0.5$	-
Coliform count	5.4×10^3	6.3×10^3	4.3×10^3	6.3×10^3	$5.6 \times 10^3 \pm 0.8$	-
Faecal coliform count	5.3×10^3	5.2×10^3	4.3×10^3	6.3×10^2	$3.8 \times 10^3 \pm 1.9$	-
Salmonella-Shigella count	5.3×10^2	5.3×10^2	3.2×10^2	4.5×10^2	$4.6 \times 10^2 \pm 0.9$	-
Vibrio count	6.2×10^2	5.1×10^2	1.2×10^1	5.7×10^2	$4.3 \times 10^2 \pm 2.0$	-
Clostridium count	6.2×10^1	6.0×10^1	3.2×10^1	6.0×10^1	$5.4 \times 10^1 \pm 1.3$	-
Staphylococcus aureus count	4.2×10^4	3.4×10^3	2.6×10^3	4.2×10^3	$1.3 \times 10^4 \pm 1.7$	-
Hydrocarbon utilization count	2.3×10^2	4.2×10^1	3.2×10^2	4.3×10^2	$1.98 \times 10^2 \pm 1.5$	-
Fungal count	5.4×10^3	5.3×10^3	4.3×10^4	5.11×10^4	$2.6 \times 10^4 \pm 2.1$	-
Dermatophytic fungal count	3.7×10^2	4.0×10^1	4.1×10^2	3.3×10^2	$2.9 \times 10^2 \pm 1.5$	-

Key: BSS1 - Beach sand station 1, BSS2 - Beach sand station 2, BSS3 - Beach sand station 3, BSS4 - Beach sand station 4.

Table 3: Bacteria pollution index of the beach environment.

	BSS1	BSS2	BSS3	BSS4	BWS1	BWS2	BWS3	BWS4
Total coliform (TC)	$5.4x10^3$	$6.3x10^3$	$4.3x10^3$	$6.3x10^3$	$6.1x10^3$	$5.2x10^3$	$4.7x10^3$	$3.5x10^3$
Faecal coliform (FC)	$5.3x10^3$	$5.2x10^3$	$4.3x10^3$	$6.3x10^3$	$1.2x10^2$	$1.3x10^2$	-	-
TC/FC ratio	1.0	1.2	1	1	50	40	4700	3500

Key: BSS1- Beach sand station 1, BSS2 - Beach sand station 2, BSS3 - Beach sand station 3, BSS4 -Beach sand station 4.
BWS 1 - Beach water station 1, BWS 2 - Beach water station 2, BWS 3 - Beach water station 3, BWS 4 - Beach water station 4.

(b) Microbial Diversity of the Beach Environment

The identified bacterial species include *Bacillus, Streptococcus, Klebsiella, Proteus, Escherichia, Vibrio, Shigella, Salmonella, Clostridium, Micrococcus, Serratia, Staphylococcus, Pseudomonas, Enterobacter* and *Chromatium*, while the identified fungal species include of *Aspergillus* sp, *Geotrichum* sp, *Penicilluim* sp, *Rhizopus* sp, *Micor* sp, *Trichoderma* sp, *Cladiosporuim* sp, *Trichophyton* sp. and *Microsporium* sp.

Table 4 shows the distribution and prevalence rate of the diverse bacteria isolated from Edonwhii beach sand. The isolates *Bacillus subtilis, Chromatium* sp, *Escherichia coli, Kebsiella* sp, *Staphylococcus aureus, Shigella* sp. and *Vibrio* sp were predominant with 100% prevalence rate while *Enterobacter aerogenes, Micrococcus, Pseudomonas* sp. and *Serratia* sp, exhibited the least (25%) prevalence rate. For the beach water samples (Table 5), the results revealed that all the bacteria that showed 100% prevalence in sand exhibited low or moderate prevalence (25 or 50%) in water. However, *Proteus* sp, that exhibited low presence in sand had 100% prevalence in water. Similar findings were recorded for fungi. Table 6 revealed low prevalence (25%) for *Epicocuum* sp to moderate prevalence (50%) for *A. candidus, A. niger, A. fumigatus, Geotrichum* sp, *Penicillium frequantus* and *Rhizopus stolonifer* in beach water samples while *A. niger, Trichoderma* and *Micosporium* were the most 100% prevalence fungal isolate encountered in the beach sand (Table 7).

Table 4: Distribution and prevalence of the diverse bacterial isolates in sandy samples from the Edonwhii beach environment.

Isolates	Stations BSS 1	BSS 2	BSS 3	BSS 4	Prevalence rate (%)
Bacillus sp	+	+	-	-	50
Chromatium sp	+	+	+	+	100
Enterobacter aerogenes	-	-	-	+	25
Escherichia coli	+	+	+	+	100
Klebsiella sp	+	+	+	+	100
Micrococcus sp	-	-	+	-	25
Pseudomonas sp	-	-	-	+	25
Proteus	+	+	-	-	50
Staphylococcus aureus	+	+	+	+	100
Salmonella sp	+	+	+	-	75
Shigella sp	+	+	+	+	100
Streptococcus sp	+	+	-	-	50
Serratia sp	-	-	+	-	25
Vibrio sp	+	+	+	+	100
Species Richness	10	10	9	8	

Key: BSS1- Beach sand station 1, BSS2 - Beach sand station 2, BSS3 - Beach sand station 3, BSS4 -Beach sand station 4.

Table 5: Distribution and prevalence of the diverse bacterial isolates in water samples from the Edonwhii sandy beach environment.

		Stations			
Isolates	**BWS1**	**BWS2**	**BWS3**	**BWS4**	**Prevalence rate (%)**
Bacillus sp	+	+	-	+	75
Chromatium sp	+	-	-	-	25
Escherichia coli	+	+	-	-	50
Enterobacter aerogenes	-	-	+	-	25
Klebsiella sp	+	+	+	-	75
Micrococcus sp	-	-	+	-	25

Proteus	+	+	+	+	100
Staphylococcus aureus	-	+	-	-	25
Staph albus	-	-	-	+	25
Salmonella sp	+	-	-	-	50
Shigella sp	+	-	-	+	50
Serratia sp	+	-	-	+	50
Vibrio sp	-	+	-	-	25
Species Richness	8	6	4	5	

Key: BWS 1 - Beach water station 1, BWS 2 - Beach water station 2, BWS 3 - Beach water station 3, BWS 4 - Beach water station 4.

Table 6: Distribution and prevalence of the diverse fungal isolates in water samples from the Edonwhii sandy beach environment.

		Stations			
Isolates	**BWS1**	**BWS 2**	**BWS 3**	**BWS 4**	**Prevalence rate (%)**
Aspergillus candidus	+	+	-	-	50
Aspergillus niger	-	-	+	+	50
Aspergillus fumigates	-	+	+	-	50
Epicocuum	-	-	+	-	25
Geotrichum candidum	+	+	-	-	50
Penicillium frequentus	-	-	+	+	50
Rhizopus stolonifer	+	-	-	+	50
Species Richness	3	3	4	3	

Key: BSS1- Beach sand station 1, BSS2 - Beach sand station 2, BSS3 - Beach sand station 3, BSS4 -Beach sand station 4.

Table 7: Distribution and prevalence of the diverse fungal isolates in sand samples from the Edonwhii sandy beach environment.

		Stations			
Isolates	**BSS 1**	**BSS 2**	**BSS 3**	**BSS 4**	**Prevalence rate (%)**
Aspergillus glaucus	-	-	-	+	25
Aspergillus niger	+	+	+	+	100
Botrytis sp	-	-	+	-	25
Cladosporium sp	+	+	-	-	50
Candida	+	-	+	+	75
Trichoderma	+	+	+	+	100
Trichophyton	+	-	-	+	50
Microsporium	+	+	+	+	100
Epidermophyton	-	+	+	+	75
Species Richness	6	5	6	7	

Key: BSS1- Beach sand station 1, BSS2 - Beach sand station 2, BSS3 - Beach sand station 3, BSS4 -Beach sand station 4.

(c) Prevalence of Helminth Eggs in the Beach Environment.

Six species of helminth eggs were detected in the faeces samples from Edonwhii sandy beach. These included *Toxocara canis*, *Ascaris lumbricoides*, *Trichoris* sp, *Necator americanum*, *Strongyloides* sp and *Enterolos* sp. All the helminth species were detected in the dog faeces while only four were encountered in human faeces (Tables 8 and 9).

Table 8: Occurrence of helminth eggs in human faeces collected from Edonwhii sandy beach.

Helminth		**Sample**				**Total**
	1	2	3	4	5	
Toxocara canis	1	1	0	0	1	3
Ascaris lumbricoides	0	2	1	2	2	4
Trichoris sp	1	0	1	0	1	3
Necator americanum	0	1	2	2	-	5

Table 9: Occurrence of helminth eggs in dog faeces collected from Edonwhii sandy beach.

Helminth	Sample					Total	Prevalence rate (%)
	1	2	3	4	5		
Toxocara canis	1	0	1	1	1	4	11.8
Ascaris lumbricoides	1	2	1	1	2	7	20.6
Trichoris sp	1	0	0	1	1	3	8.8
Necator americanum	4	2	2	2	3	13	38.2
Strongyloides sp	2	0	1	0	1	4	11.8
Enterolos sp	1	0	1	0	1	3	8.8
Total	10	4	6	5	9	34	

3.2 Physicochemistry of the Beach Environment

(a) Physicochemical Attributes

Results of the physicochemical parameters of the beach sand and water samples analysed are presented in Tables 10 and 11 respectively. The pH of the sand ranged from 6.7 - 7.4 with mean value of 7.0±0.19. Total organic carbon (TOC), total nitrogen (TON) and available phosphorus levels of 1.8%, 0.25% and 1.69mg/kg recorded respectively were quite low. Low levels of exchangeable cations were also observed. The levels of Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+} recorded were 6.97±0.38mg/kg, 2.89±0.46mg/kg,7.69±1.16mg/kg and 0.16±0.02mg/kg respectively. The results also revealed the concentration of total recoverable hydrocarbons ranged from 9.38mg/kg to 10.44mg/kg. The sandy beach was predominantly sandy, 80.84-81.22% although 12-13.02 % of clay and 5.54-6.64% of silt were also recorded.

Table 10: Physicochemistry of the beach sand samples.

Parameters	Stations			Mean ±SD	WHO LIMIT	
	1	2	3	4		
pH	6.7	7.4	6.9	6.9	7.0 ± 0.19	6.5 –8.5
Total Organic Carbon (%)	1.7	2.11	1.65	1.7	1.8 ± 0.3	-
Avail Phosphorus (mg/kg)	1.5	2.24	1.31	1.71	1.69 ± 0.67	-
Total Nitrogen (%)	0.26	0.25	0.27	0.21	0.25 ± 0.02	-
Exchangeable Cation (mg/kg)						
Ca^{2+}	7.31	6.34	7.22	7.02	6.97 ± 0.38	50
Mg^{2+}	3.31	2.11	3.14	2.99	2.89 ± 0.46	250
Na^{+}	9.16	7.88	5.92	7.8	7.69 ±1.16	250
K^{+}	0.14	0.15	0.18	0.17	0.16 ± 0.02	250
Nutritive Salts						-
Cl^{-}	3.8	3.6	6.21	4.14	4.44 ± 1.03	-
SO_4^{2-}	19.42	19.10	18.56	20.28	19.34 ± 1.41	250
NO_3^{-}	28.88	24.6	27.3	19.49	25.07 ± 3.57	-
Salinity	2.7	2.58	2.57	2.86	2.68 ± 0.12	-
Total Hydrocarbon content (m/l)	10.44	9.38	10.11	10.21	10.04 ± 0.39	-
Particle size distribution (g/l)						
Sand	81.21	80.11	81.22	80.84	80.85 ± 4.0	-
Silt	5.54	6.64	6.54	6.24	6.24 ± 4.0	-
Clay	13.02	13.02	12.00	12.68	12.68 ± 3.99	-

Table 11: Some physicochemical properties of water samples from the sandy beach.

Parameters		Stations			Mean ± SD	WHO Limit	DPR	FME
	1	2	3	4				
Temperature (^{o}C)	24.3	25.1	23.9	24.5	24.45 ± 0.43	25-30	30	35
pH	6.93	6.71	6.79	7.2	6.91 ± 0.19	6.5-8.5	6.5-8.5	6.5-8.5
Salinity (g/l)	8.7	7.6	8.3	9.2	8.45 ± 0.58			
TDS (mg/l)	84.6	66.5	73.4	74.9	74.85 ± 6.46	1000	5000	-
Alkalinity (mg/l)	1025	1019	1022	1009	1018 ± 6.02	100	-	-
Hardness (mg/l)	17,000	16,047	17,101	16,444	16648 ± 427.76	500	-	-
Nitrate (mg/l)	0.249	0.261	0.199	0.242	0.238 ± 0.07	10	-	-
Phosphate (mg/l)	0.325	0.333	0.2777	0.217	0.288 ± 0.05	-	-	-
Sulphate (mg/l)	201.6	200.4	192.7	189.3	196 ± 5.16	250	-	-
DO (mg/l)	5.83	5.44	5.71	5.62	5.65 ± 0.14	5	-	-

BOD_5 (mg/l)	11.13	9.34	10.66	11.02	10.54 ± 0.71	6	125	10
COD (mg/l)	13.99	10.79	12.44	9.44	11.67 ± 1.71	10	125	40

DISCUSSION

Microbiological examination of water is used worldwide to monitor and control the quality and safety of various types of water including bathing waters. The aim is to consider evidence for the relationship between microbiological quality of water and risk to human health. This involves amongst other things the isolation and identification of diverse microbial groups including potential pathogens associated with the water. Though it is impractical to screen samples for all possible pathogens, however, several indicator organisms have been used as surrogate markers of risk. The present study has revealed the occurrence of aerobic bacterial population in Edonwhii beach sand and water. However, the presence of both total coliforms and faecal coliforms is indicative of faecal pollution (Umana *et al.*, 2017) and while the presence of hydrocarbon utilizing bacteria suggests availability of petroleum hydrocarbons in the environment as a result of either natural or anthropogenic activities involving oil production in the nearby vicinities (Umana *et al*, 2017).

Studies on the effects on health of swimming at bathing beaches carries some risk of illness even when the beach complies with existing legislative standards. The risk to health increases in proportion to the amount of faecal population as measured by indicator organisms. In the present study, faecal coliform organisms that grew at 44^{o}C were regarded as more specific indicators of faecal contamination than total coliforms which were counted at 37^{o}C.

Drinking water guideline values (WHO, 1998) relate to water ingestion and, in most cases, to life time exposure, thus, drinking water guidelines may be related to recreational exposure. For this reason, it is suggested that environmental quality standards for biochemicals in recreational waters should be based on the assumption that recreational water makes only a relatively minor contribution to intake. It is assumed a contribution for swimming of an equivalent of 10% of drinking water consumption. Since most authorities (including WHO) assume consumption of 2 litres of drinking water per day, this would result in an intake of 200ml per day from recreational contact with water. The presence of total coliforms in higher concentrations than the indicator microorganisms related to faecal contamination, such as feacal coliform and faecal streptococci, suggested that the pollution was not of faecal origin exclusively (Al-Jebouri and Trollope, 1984).

However, the ratio between total coliform (TC) and faecal coliforms (FC) has been used as an approximate index to establish the proportion of TC with exclusively faecal origin. A TC/FC value of more than one (1) indicates that all the total coliforms are from a faecal source as opposed to other possible sources such as soil, vegetations, insects etc. In this study, this index was higher than I in both beach water and beach sand, suggesting that the faecal pollution of water and sand of Edonwhii beach was due to their presence in faeces. However the high incidence of the faecal coliform count is a pointer to the high densities of the *Salmonella-Shigella* loads of the beach water and sand samples.

On the other hand, the isolation of hydrocarbonoclastic bacteria from both beach sand and water is indicative of exposure of the indigenous bacterial population to pollution with crude petroleum or its products in the environment. The study has also showed that Edonwhii beach sand and water do harbor diverse microbial assemblage including potential pathogenic species. This finding is in conformity with observations of Alm *et al*. (2003) who concluded that wet and dry beach sands and water in diverse climates and with diverse geographies are reservoirs of a variety of microorganisms including *Enterococcus* and *E. coli.* However, the presence of *E. coli* is indicative of the possible pathogenicity of the *Klebsiella, Shigella, Salmonella*, and *Clostridium* species isolated from the beach environment. The high incidence of *Staphylococcus aureus* count is pointer to high level of human impact. This was apparent by the activities of kids involved in football and other sporting activities. *Staphylococcus* is a normal skin flora and commonly associated with food poisoning. Interestingly, apart from the occurrence of bacteria associated with gastrointestinal perturbations, the proliferation of others such as dermatophytic fungi that could cause topical skin disease when in contact with dermal surfaces is worthy of note. The potential health risk associated with the exposure to contaminated beach sand and water at Edonwhii is high especially for the most vulnerable including women, the very young, the very old and those with compromised immune status. The detection of some fungi in samples from the ecosystem should be considered relevant since skin and mucous membrane infections could result from contact with *Trichophyton, Epidermophyto*n and *candida* found in contaminated sand and water. This holds true when considered in the light of previous report by Kay and Jones (1992), who noted an increase in thrush infection amongst women holidaying at a seaside. Species of *Microsporium* and *Trichophyton* have been associated with ringworms of human body, while *Candida albicans* has been implicated with candidiasis and depletion of human nails known as paronychia (Bernard *et al*., 1988).

This study has also revealed the prevalence of eggs of four helminthic species (*Taxocaracanis, Ascaris lumbricoides, Trichoris* sp and *Necator americanum*) in the beach environment. Water and soil borne parasitic organism of human concern associated with beaches and sand, are generally disseminated into the environment in the feaces or urine of infected animals or humans.

According to Wright *et al.* (2009), it is assumed that common sources of these pathogens at beach sites include dogs and birds. In addition, the habit of the settlers at the fishing settlement including indiscriminate excreta disposal could also be a major source. The robust parasitic stages are capable of persisting for an extended period of time in the environment and are highly resistant to treatment. Toxocarosis and Ascariasis are zoonotic diseases caused by the larvae of the helminthic worms, *Toxocara* and *Ascaris.* These ascarid roundworms have worldwide distributions. Species of *Toxocara* having human and animal health significance are essentially represented by *Toxocara canis* and *Toxocara cati*, parasites of canids and felids, respectively, while that of *Ascaris* are represented by *Ascaris lumbricoides*, parasite of the swine. These animals form part of the domestic environment of the settlers and roam freely. In this sense, these animals disseminate these parasites as they defeacate in the environment. Finally, parasites may reside on the sand surface, in crevices, or in biofilms that adhere to sand and can complicate pathogen quantification.

The physicochemical properties of the ecosystem reveal the beach sand as having near neutral pH, while the beach water was slightly acidic. Both values were within the WHO acceptable limits for costal soils. pH has been established as a major determinant of microbial activities, abundance of trace elements and partitioning of chemical substances in environmental matrix. It also serves as an indicator parameter for deducing the availabilities of exchangeable cation (N^{+}, K^{+}, Mg^{2+} and Ca^{2+}), which are essential elements required to ensure optimal primary and secondary productivity and are usually absorbed by electrostatic or coulombic attraction to surface colloids. The sandy beach environment of the studied area contained very low levels of these cations and these in turn may be responsible for the low availability of total organic carbon, available phosphorus, total nitrogen and nutritive salt levels that are very necessary for microbial growth and multiplication.

The particle size analyses reveal the textural characteristic of the study area to be largely of sand fractions. This in turn determines the water intake rate and nutrient absorption rate, water storage, amount of aeration and seepage. This sandy nature influences the beach sand fertility and may be responsible for the low microbial populations observed. Further analyses revealed that the total recoverable hydrocarbons in the studied samples was far higher than analytical method detection limit of 5mg/kg indicating that the area was not free from hydrocarbons pollution. This finding could serve as a confirmation of the selective pressure that led to the isolation of hydrocarbonaclastic species and the general reduction in densities of heterotrophic bacteria in the area. Results in this study collaborate with earlier observations obtained for similar habitats by RP1 (1985).

CONCLUSION

Environmental factors and sanitary conditions of sandy shores including the hydrometeorological and physical/chemical parameters as well as solar insolation and tidal influence, may all impact the levels of microbial activities in Edonwhii beach sand and water. In addition to public health concerns to beachgoers, one must also consider occupational hazards for the fisher-folks. Their exposure time to fungal, bacterial and helminthic species present in sand and water is increased due to their professional activities (fishing). In this study, it has been possible to establish the presence of yeasts, pathogenic fungi, dermatophytes, total coliforms, *E. coli*, and helminthic eggs in the sandy beach of Edonwhii fishing settlement. The data provide useful baseline information for assessment of the health status of the sandy beaches and can serve as reminder of the occurrence of potentially harmful fungi and bacteria in our local beaches.

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