MICROBIOLOGICAL QUALITY ASSESSMENT OF SUDANESE COASTAL SEA-WATERS WITH SPECIAL REFERENCE TO PORT SUDAN AREA

Ehab Omer Abdalla*[1] and Mohammed Taha Abdalla Shigidi [2]

[1]Department of Biological Oceanography, Faculty of Marine Sciences and fisheries, Red Sea University

[2]Department of Microbiology, Faculty of Veterinary Medicine, University of Khartoum

المستخلص

أجريت هذه الدراسة بهدف تقييم درجة التلوث البرازي للمياه الساحلية السودانية بالقرب من بورتسودان وذلك بتقدير ورصد أهم مؤشرات التلوث بالمخلفات البرازية في مياه البحر والتي هي بكتريا القولون الكلية و بكتريا القولون البرازية والبكتريا العقدية البرازية، بطريقة الأنابيب المتعددة لمعرفة العدد الأكثر إحتمالا لعدد البكتريا في 100ملي ماء بحر.

جمعت 50 عينة من مياه البحر من 10 محطات أختيرت لجمع العينات يقع بعضها على خط الساحل بالقرب من بورتسودان وأخرى في المياه الداخلية لكل من بورتسودان وسواكن بالإضافة إلى محطة تقع في المياه المفتوحة لمدينة بورتسودان.

وجدت المؤشرات البكترية الثلاث في معظم العينات لكنها كانت أكثر في عينات المياه الداخلية لبورتسودان في كل من خور سلالاب وخور كلاب والتي تستقبل سنويا كميات معتبرة من المياه العذبة القادمة من اليابسة، وقد لوحظ أن هذا التواجد يتناقص كلما إبتعدنا عن بورتسودان شمالا أوجنوبا على طول خط الساحل.

الدراسة أظهرت أيضا أن هناك تواجدا أقل للمؤشرات البكترية في سواكن عما هو عليه في بورتسودان كما أن أعلى معدل لتواجد هذه البكتريا كان في حدود 180 و 180 و 350 بكتريا في كل 100 ملي ماء بحر لكل من بكتريا القولون الكلية و بكتريا القولون البرازية والبكتريا العقدية البرازية على التوالي.

في المياه الساحلية من الصعب تحديد مصدر التلوث لأن عدة مصادر قد تتداخل مع بعضها لكن في هذه الحالة من المحتمل أن تكون المياه المتدفقة من اليابسة هي المصدر الأهم بدليل

[1] **Corresponding Author: Ehab Omer Abdalla, e-mail: ehab.omer@yahoo.com**

الأعداد الكبيرة للمؤشرات في المياه الداخلية التي تستقبل التدفق من اليابسة.

Abstract

This study was carried out to evaluate faecal pollution in the Sudanese coastal waters near Port Sudan by counting the most important three bacterial indicators of faecal pollution of water which are total coliform, faecal coliform and faecal streptococci using the multiple tube technique to determine the most probable number of indicator bacteria in 100 ml sea water.

Fifty sea water samples were collected from 10 stations located along the shore line of the Sudanese coastal waters near Port Sudan as well as the inner waters of both Port Sudan and Suakin and from the open sea water in about five km from Port Sudan.

The three indicator bacteria were present in all samples collected from the shore line stations, but none of them was found in the 5 samples collected from the open sea. High counts were observed in the samples collected from the inner waters of Port Sudan in both Khour Salalab and Khour Kilab which receive annually considerable amounts of fresh water from the run–off from the land. The counts decreased when samples were collected away from Port Sudan either to the south or north.

The study showed low counts of indicator bacteria in Suakin inner waters than those of Port Sudan and the highest counts of the indicators observed in this study were 180, 180 and 350 bacteria per 100 ml sea water for total coliform, faecal coliform and faecal streptococci, respectively.

In coastal waters it is difficult to determine the exact source of pollution as many sources combine together, but in this case probably the run-off from land might be the main source due to the high counts in the inner waters which receive the run-off from land.

Key words: Coastal sea water, Bacteria, Faecal pollution.

Introduction

Faecal contamination of coastal waters is one of the most serious and well–known forms of pollution, mandating closure of large areas to shell fishing and creating a potential human health threat.

Swimming in coastal waters is favored in many countries. Such waters are often contaminated by human sewage as a result of discharges or overflows (U S Environmental Protection Agency, 2001). Swimming in faecally contaminated recreational waters has consistently been associated with gastrointestinal (GI) illness (Pruss, 1998 and Wade *et al*., 2003). The incidence of illness attributable to recreational water exposure appears to be increasing.

Bacterial pollution in coastal waters is caused by a combination of point and non–point sources of pollution. Although point sources of bacterial contamination (e.g., industry, waste water treatment facilities) are significant, non–point source pollution poses a much greater threat to the integrity of recreational water bodies because it comprises a diverse mixture of chemical and biological contaminants and is discharged from countless undefined sites within a given watershed. The USEPA (2000) states that non–point sources of pollution are the greatest threat to the nation's water quality.

Traditionally, total and thermotolerant coliform have been most widely used as indicators of faecal contamination; however, they have been shown to have shorter survival times than certain pathogens e.g., *Salmonella typhimurium* and *Yersinia enterocolitica* in cold waters (Smith *et al.*, 1994). In addition, they give no indication of health risks from protozoa and viruses. For example, indicator bacteria seldom correlate with human enteric virus distribution in seawater (Jiang *et al*., 2001). *E. coli* has also been shown to rapidly enter the "viable but nonculturable" (VNC) state in marine waters (Xu *et al*., 1982). In an epidemiologic study, Cabelli, *et al*. (1979) analyzed sea water for coliform, enterococci, *Pseudomonas*, and *Clostridium* as possible indicators. They found that gastrointestinal illness in swimmers was correlated with enterococci levels.

This study was carried out to investigate the quality of Sudanese coastal sea-waters especially near Port Sudan by determination the degree of faecal pollution of recreational waters using indicator bacteria.

Materials and Methods

The study area

Water samples were collected from different stations along the coastal line and the open waters of the Red Sea. Nine stations of sample collection were located at Port Sudan area (fig.1)– the first five samples was from the open sea – whereas the 10th five samples were collected from Suakin.

From each station five samples were collected each spaced at distances of about 100 m from the other along the coastal line.

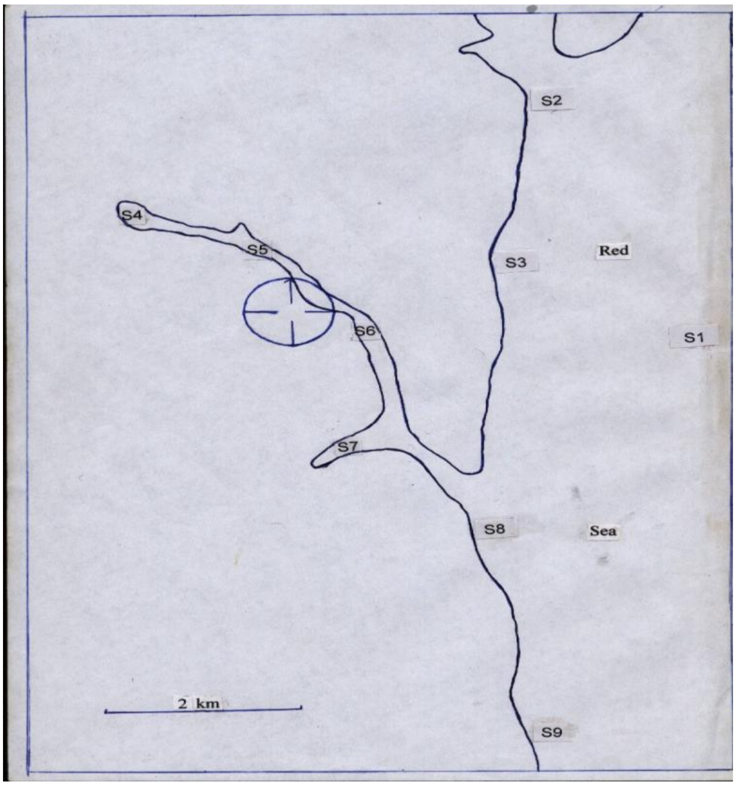

Fig. 1: The sites of sample collection in Port Sudan area No.1 - 9

s : station

Sampling

Sampling was performed according to the method of Cheesbrough (2000).

Samples were collected during three months and each five samples were collected in one day between 8-9 AM and were transported as soon as possible to the laboratory and examined within 2 hr or refrigerated (Regional Organization for the Protection of the Marine Environment, 1999).

Determination of total coliform and faecal streptococci in sea water

The multiple–tube method was used for the determination of total coliform in coastal waters.

The method followed was as described by WHO (1998).

Eijkman test (Eijkman, 1904) was done to confirm that the coliform bacilli detected in the presumptive test were *E. coli* (faecal coliform).

The multiple–tube method was also used for the determination of faecal streptococci in coastal waters.

The method followed was as described by ROPME (1999).

Results

Indicator bacteria counts per 100 ml sea water

The three indicator bacteria used to assess the microbiological quality of sea water showed considerable variation between the stations and between the areas. High counts of indicator bacteria were observed in stations 4, 5, 6 and 7 which are located in the inner waters of Port Sudan area (khour Salalab and khour Kilab) whereas low counts of indicator bacteria were observed in both shoreline samples of Port Sudan area (stations 2, 3, 8 and 9) and in the inner waters of Suakin (station 10). Indicator bacteria were not observed in station 1 which was located in the open sea water near Port Sudan area (Tables 1,2and3).

Table 1: Total coliform counts per 100 ml sea water in different five samples from different stations

SAMPLE NO.	STATION NO.									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
SAMPLE 1	0	7	35	18	180	43	43	92	35	9
SAMPLE 2	0	22	18	54	92	35	21	54	11	18
SAMPLE 3	0	3	5	92	35	43	180	22	1	22
SAMPLE 4	0	10	35	12	43	92	43	14	35	5
SAMPLE 5	0	1	7	180	43	161	21	3	43	1
Mean	0.0	8.6	20.0	71.2	78.6	74.8	61.6	37.0	25.0	11.0

Table 2: Faecal coliform counts per 100 ml sea water in different five samples from different stations

SAMPLE NO.	STATION NO.									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
SAMPLE 1	0	5	28	14	161	35	43	18	24	1
SAMPLE 2	0	3	12	5	92	35	21	17	11	7
SAMPLE 3	0	0	5	18	35	35	43	5	1	17
SAMPLE 4	0	7	28	9	28	28	43	11	35	3
SAMPLE 5	0	0	5	180	35	35	21	3	35	1
Mean	0.0	3.0	15.6	45.2	70.2	33.6	34.2	10.8	21.2	5.8

Table 3: Faecal streptococci counts per 100 ml sea water in different five samples from different stations

SAMPLE NO.	STATION NO.									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
SAMPLE 1	0	4	225	175	140	275	55	0	5	4
SAMPLE 2	0	4	25	20	225	275	225	2	50	20
SAMPLE 3	0	2	12	4	45	45	275	0	2	20
SAMPLE 4	0	4	30	30	45	170	225	0	13	0
SAMPLE 5	0	2	17	225	40	350	250	0	9	0
Mean	0.0	3.2	61.8	90.8	99.0	223.0	206.0	0.4	15.8	8.8

Discussion

Indicator bacteria were found abundantly in the inner coastal waters of Port Sudan which included both Khour Salalab and Khour Kilab, and were less abundant in the coastal waters along the coastal line of Port Sudan and the inner water of Suakin. The examinations showed that indicator bacteria decreased in number when samples were collected further north or south along the coastal line from Port Sudan. Indicator bacteria were not found in the open sea water near Port Sudan and were less abundant in Suakin than Port Sudan. These findings suggest that these bacteria might most properly have originated from faecal materials of human or animal sources.

The low presence of indicator bacteria in the inner waters of Suakin is mainly due to the low human population who live there when compared with Port Sudan. The low presence of indicator bacteria in Port Sudan coastal water when compared with the inner water is probably due to low exposure to the faecal materials and the ability of the open waters for self cleaning and dispersion as a result of the waves and currents.

The high counts of indicator bacteria in the inner sea waters of Port Sudan may be due to the enclosed character of the area, so the waste may not be rapidly diluted and dispersed by natural processes that happen in the open water and this agrees with FAO report (1979) which attributes the accumulation of marine pollutants to the enclosed character of some parts of the seas.

In the Sudanese coastal waters as in other parts of the world, it is difficult to determine the exact source of faecal pollution because many sources combine together to pollute these waters. Probably the run–off from the land may be the main source of faecal pollution because, as in the case of the inner waters of Port Sudan, this area receives annually considerable amounts of fresh water from the land during the flood seasons. These floods sweep the lands carrying every things to the sea, especially the faecal materials that are found abundantly around this area due to the poor hygienic conditions of the population. A considerable part of these populations are nomads who live into the rural area around and also inside the city and have no sewage system in their homes.

Additionally, considerable amounts of faecal materials are added to the coastal waters by the contributions of the boats, especially tourist boats that anchor in the inner waters at khour Kilab and release their sewage directly in the water without any treatment processes.

The presence of indicator bacteria in high counts in the inner waters of Port Sudan may be due to the presence of large amounts of inert material (e.g., bottles, tires, plastics) supporting biofilms that may provide protective niches for bacteria and viruses, prolonging their marine survival (Colwel and Spira, 1992).

Seabirds are found in big numbers in the inner waters of Port Sudan area. They come to this area in order to feed on small fishes found there because the area is suitable for fish spawning. These birds may have contributed largely to the high counts of indicator bacteria found in this area. Furthermore, not far from this area, there are many cattle farms that may also contribute by their faecal materials in polluting sea waters in this area when washed away with fresh water run–off from the land.

Maki (1993) found that determinants of bacterial growth and survival in marine waters are salinity, temperature, predation, sunlight (ultraviolet), toxic chemicals, and nutrients. The more favorable ranges of these determinants for microbial growth can often be found in estuaries (Ducklow and Shiah, 1993). Indeed, the high nutrient content found in some coastal waters can override the stresses of suboptimal salinity and/or temperature, prolonging bacterial survival (Singleton *et al*., 1982). These attributes could partially explain the situation in Port Sudan inner waters area although it cannot be considered as an estuary.

The point of valuable importance that has to be mentioned here is that humid weather of Port Sudan and the Red Sea coast in general, except during summer seasons, can contribute largely to the survival of indicator bacteria outside of the water system and increase their chances to reach the sea.

Some tropical environments, both marine and fresh water, have been observed to have high densities of coliform even when no contamination source was apparent (Lavoie, 1983). However, in this study, the absence of indicator bacteria from the open sea waters is strong evidence of faecal pollution of human or animal origin of the inner waters.

With respect to indicators relationships, the ratio of faecal coliform to faecal streptococci FC/FS for all sea water samples with the exception of sample 2, station 8 (which is 8.5) generally fell within the limits 0.08–4.8. This range indicated that faecal pollution was due to waste of mixed human and animal sources according to the FC/FS ratio limits (Wilkes University, 1998).

The faecal coliform segments of total coliform populations for all sea water samples were in the range of 9% to 100% (the mean is 70%). This mean is slightly lower than the percentage patterns in faecally polluted water samples by either human (96%) or animal (93–98%) (Geldreich, 1976). This may be due to presence of some coliform capable of natural occurrence and survival in the environmental samples (Caplenas and Kanarek, 1984).

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