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ASSESSMENT OF MARINE WATER QUALITY AND ITS SUITABILITY FOR RECREATIONAL ACTIVITIES IN PASIKUDAH BEACH

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ABSTRACT

Coastal waters are used for a variety of leisure and recreational activities. Water pollution can significantly reduce the demand for recreation. Assessment of recreational water quality is a useful tool in pollution control and developing mitigation measures. The present study was undertaken with the view of assessing marine water quality of Pasikudah beach to evaluate suitability for recreational activities, identify pollution sources and possible mitigation ways to solve pollution issues. The research was carried out monthly for 06 months period from June to December 2017. Marine water quality results revealed that average pH (8.03), Turbidity (9.94NTU) and temperature (30.2 ^{0}C) values were within the recommended threshold limits. Electrical Conductivity (EC) and salinity ranges were 46.46- 58.16mS/cm and 27.63- 33.52PSU respectively. Electrical conductivity and salinity had a positive correlation, and It was noted that salinity and EC values were lower on November and December than other months due to rainfall which causes dilution of salts. Also, Measured Dissolved oxygen values (6.23-8.21mg/l) were above the minimum required level (4mg/l). This study suggests that the experimental sites were not experiencing any oxygen deficiency at that time. Recorded nitrate and phosphate value ranges were 0- 2.8mg/l and 0.13- 4.51mg/l with the mean value of 0.63 and 1.36mg/l respectively and these values exceeded the standard values for the recreational site. Substances such as fertilisers and detergents carried by Pasikudah canal, sewage and stormwater runoff during the rainy season may be reasons which increase nutrients level in seawater. Total Coliform and Escherichia coli counts were ranges between 0-93 and 0-40MPN/100ml with the mean value of 16 and 6MPN/100ml respectively and measured values were within threshold limits. So, based on overall results; Pasikudah beach is suitable for recreational activities.

Keywords: marine water quality, water pollution, recreational water, pollution source

Introduction

Bodies of water, particularly the coastal oceans and the great lakes, provide a source of food, employment, recreation and residence, and are the first defense from various natural and man-made hazards and disasters. Maintaining these as functional and healthy ecosystems is essential for our future well-being (Shuval, 2006).

[227] Marine Environment Protection Authority, Ampara.

Tourism and recreation are becoming increasingly important economic sectors in many coastal areas (Bartram and Rees, 2000). Recreational use of inland and marine waters is increasing in many countries. It is estimated that foreign and local tourists together spend around two billion days annually at coastal recreational resorts (Shuval, 2003). Beach recreationalists generally look for safe and clean bathing environments in which to undertake their activity (Saunders *et al.*, 2000).

It is relatively recently that participation in recreational activities has grown to the extent that it has been linked to declining environmental quality in certain areas (Saunders *et al.*, 2000). As growing numbers of persons move to coastal areas and pollution continues to threaten the waters in which we swim and play, many people still risk illness from exposure to contaminated recreational waters (EPA, 1999).

Sri Lanka is acutely facing deterioration in coastal water quality problem mostly due to increased human population, rapid urbanization, industrial activities and intensive agricultural practices. Coastal water pollution is caused both by land based and sea based activities. In Sri Lanka, roughly 90% of marine pollution is on account of land based and only 10% is sea based (Prematunge, 2009).

Monitoring recreational waters is important in identifying the risk to recreational waters and public health. As water quality problems become more widespread, water quality monitoring will necessarily become a more important component of national water resources management programmes (UNICEF, 1999).

Pasikudah beach is ideal for bathing as the sea is clear, calm and reef-protected. This beach is very popular among visitors due to the calm clear waters which are ideal for swimming and boating activities. Present study was undertaken with the view of assessing marine water quality of Pasikudah beach to identify pollution sources, level of pollution and suggest possible pollution control measures.

Methodology

Location of the study

The study was conducted in Pasikudah beach which is located around 35km away from the Batticaloa town and is ideal for bathing as the sea is clear, calm and reef-protected. This beach is very popular among visitors due to the calm clear waters which are ideal for swimming.

Water sampling and Analysis

The shallow water depth around chest depth along the near- shore area was subjected to monitoring. Around 550m stretch of the beach area was subjected to monitoring and samples were collected at 50m gap along the beach area using systematic line sampling method. Study was carried out for a period of 06 months period from 10^{th} of June to 10^{th} of December, 2017 and sampling was done on monthly basis in 12 sampling points along the coastal stretch according to their GPS points. The relative sampling locations are illustrated in Figure 2.1.

Samples were collected in morning at 9.30am to 10.30am on every month during research period in order to ensure the sample collection at regular interval. Temperature, Electrical Conductivity (EC), Salinity, Total Dissolved Solids (TDS), p^H and Dissolved Oxygen were measured by using multi meter (Orion Star A329 portable pH/ISE/Conductivity/DO meter) and turbidity was measured by using turbidity meter (Hatch 2100Q Portable Turbidimeter). Measurement of nitrate and phosphate concentration was done with the support of National Water Supply and Drainage Board (NWSDB), Sagamam. All the equipments used for the measurements were subjected to calibration before every sampling day.

Microbiological sampling

12 Samples were collected at approximately 15cm below the surface at a point where the depth of the water is approximately 0.5 meters (knee depth) by using sterilized glass bottles in each sampling point. The sample bottles were transported to the laboratory in regifoam box filled with ice. The microbial test was done at National Water Supply and Drainage Board, Sagamam. To enumerate *Escherichia coli* and Total Coliform counts Membrane Filtration (MF) Method was adopted.

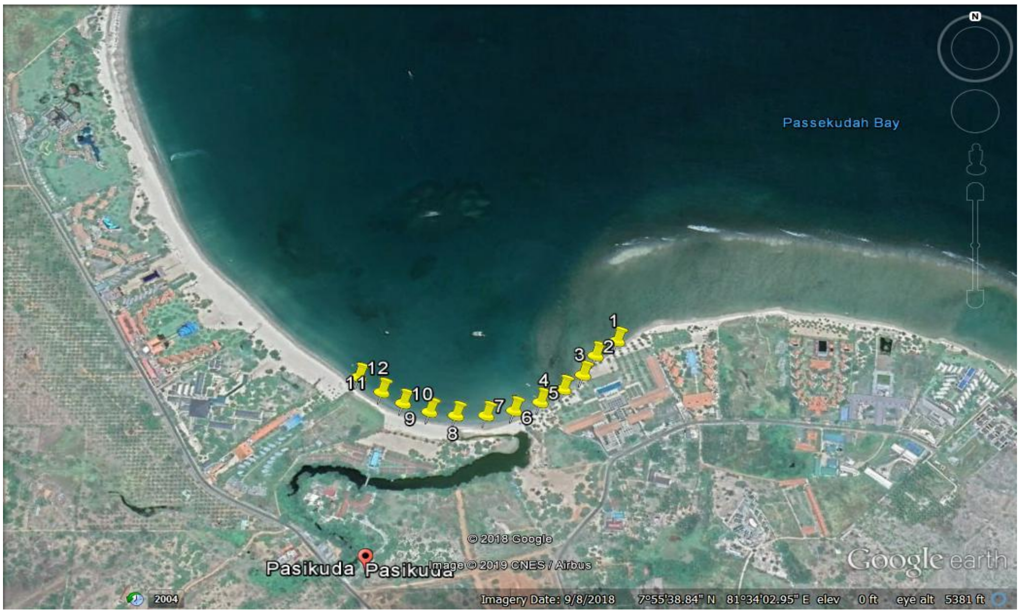


Figure 2.1: sampling locations in Pasikudah beach

Results and Discussion

Recommended marine water quality standard values of recreational sites and minimum, maximum and mean values of overall results

Water-quality guidelines are necessary to protect human health during recreational activities and to preserve the aesthetic appearance of water bodies. Such guidelines are used to determine whether water body is suitable for recreational use (NHMRC, 2008). In Sri Lanka, there is no ambient marine water quality standard for recreational site until now. Therefore, I used the recreational marine water quality criteria of some countries for comparison of results. Table 3.2 outlines the guideline values for the recommended water quality parameters for marine recreational sites in some countries. Table 3.1 shows the minimum, maximum and mean values of overall results obtained and table 3.3 shows the monthly mean value of each parameter.

Table 3.1: Minimum, maximum, mean and standard deviation values of results

Parameter	Unit	Minimum	Maximum	Mean
P^H	-	7.76	8.29	8.03
Turbidity	NTU	4.67	16.13	9.94
Total Dissolved Solids	ppt	22.77	28.83	26.38

Electrical Conductivity	mS/cm	46.46	58.16	53.80
Salinity	PSU	27.63	33.52	31.60
Dissolved Oxygen	mg/l	6.23	8.21	7.17
Temperature	^{0}C	25.6	33.9	30.2
Nitrate	mg/l	0	2.8	0.63
Phosphate	mg/l	0.13	4.51	1.36
Total Coliform counts	MPN/100ml	0	93	16
Escherichia coli counts	MPN/100ml	0	40	6

Table 3.2: Recommended marine water quality standard values for recreational site in different countries

Parameters	**India**	**Malaysia**	**Japan**	**Australia**
P^H	6.5- 8.5	-	7.8-8.3	6.5-8.5
Turbidity	<30 NTU	-	-	-
Dissolved Oxygen	≥4mg/l	≥5mg/l	≥7.5mg/l	≥6mg/l
Total Dissolved Solids	-	-	-	-
Electrical Conductivity	-	-	-	-
Salinity	-	-	-	-
Temperature	-	≤2°C increase over maximum ambient temperature	-	16-34^{0}C
Nitrate	-	60µg/l	-	-

Phosphate	-	75 µg/l	-	-
Total Coliform counts (per 100ml)	-	-	<1000	-
Escherichia coli counts (per 100ml)	<100	<100	-	<150

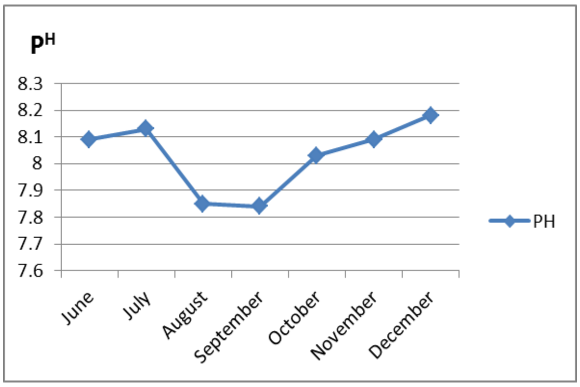
(Sources: MEF, 1998; Health Canada, 2012; MONRE *et al*.,2003; DOE, 2010; NHMRC, 2008; EPD, 2008; Snidvongs *et al*., 2002)

Table 3.3 Monthly mean values of water quality parameters

Parameter	June	July	Augu	Septe	Octob	Nove	Dece
P^H	8.09	8.13	7.85	7.84	8.03	8.09	8.18
Turbidity (NTU)	8.55	9.19	9.28	9.91	9.48	10.09	13.04
Electrical Conductivity (mS/cm)	55.75	57.29	55.08	55.70	56.95	48.64	47.17
Salinity (PSU)	32.65	33.10	32.91	33.19	32.93	28.38	28.03
Dissolved Oxygen (mg/l)	7.05	7.95	7.11	6.78	7.03	7.05	7.21
Temperature (^0C)	30.8	33.7	29.9	29.5	31.8	26.3	29.3
Nitrate (mg/l)	0.009	0.09	0.051	1.310	0.851	1.875	0.197
Phosphate (mg/l)	0.337	0.256	0.480	2.258	2.042	2.242	1.888
Total Coliform counts (MPN/100ml)	5	8	5	18	10	56	11
Escherichia coli counts (MPN/100ml)	3	2	2	9	1	24	3

Comparison of P^H and Turbidity values with standard values and its monthly variation

Based on table 3.1, minimum and maximum values of pH were 7.76 and 8.29 with the mean value of 8.03. Recommended Indian water quality criteria for P^H is 6.5-8.5 (Table 3.2). So, measured values are within the threshold limits. Both alkaline and acidic waters may cause eye irritation. To be protective against the risk of eye irritation, the pH of recreational waters should be in the range of 5.0 to 9.0 (Health Canada, 2012). Figure 3.1 shows the monthly variation in pH values.



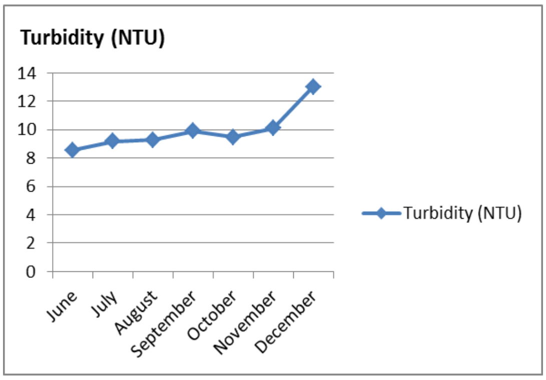


Figure 3.1: Monthly variation in pH *Figure 3.2: Monthly variation in turbidity*

Turbidity is important for aesthetic, safety and, to a lesser degree, health reasons. High turbidity is aesthetically displeasing and can be a safety concern when it reduces visibility through the water. Lifeguards and other persons near the water must be able to see and distinguish people in distress. In addition, swimmers should be able to see quite well while under water (Health Canada, 2012).

Turbidity values obtained were ranging from 4.67 to 16.13 with mean value of 9.94NTU. Indian water quality standard value for turbidity is 30NTU; so, measured values are within the recommended values. TSS and turbidity are changed due to the watershed hydrologic process, soil sediment characteristics and land use pattern (Amarathunga *et al*., 2010). The high turbidity and TSS values could have been caused either by extensive soil erosion within the watershed and it flow in to the coastal water through river or canal (Hettige *et al*., 2014). Based on table 3.3 turbidity values are higher on November and December than other months. It may be due to surface runoff during rainy season.

Comparison of Electrical Conductivity, Salinity, Dissolved Oxygen and Temperature values with standard values and its monthly variation

Measured value range for Electrical Conductivity (EC) and salinity were 46.46- 58.16mS/cm and 27.63- 33.52PSU respectively. There is no water quality standard for conductivity, but conductivity can be a useful diagnostic tool for interpreting other water quality information. For example, domestic and industrial wastewater, storm water, and irrigation return water often have higher conductivities than the receiving streams (ODEQ and ODF, 1996).

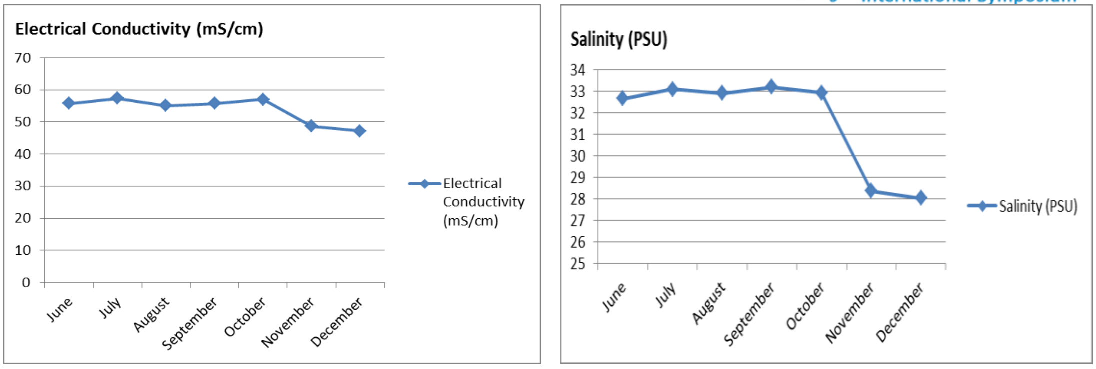
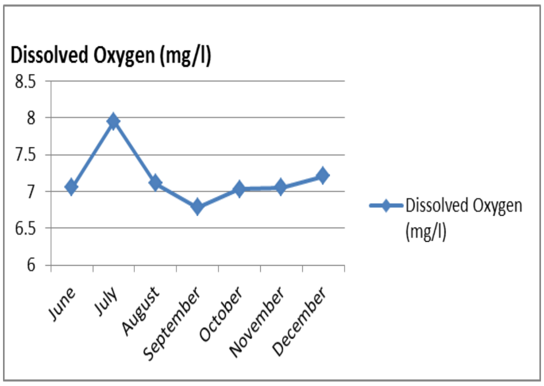


Figure 3.3 and 3.4: Monthly Variation in Electrical Conductivity and Salinity

Generally salinity value for sea water is 35g/kg (or 35PSU). Salinity is an indication of the concentration of dissolved salts in a body of water. In coastal waters, salinity is often used to trace the mixing of freshwater (including sewage outflows) with seawater. Salinity can also be used to find where a sewage outfall is mixing with the sea and the direction of the effluent plume (DEFA, 2007). During wet periods, salinity and conductivity will decline as the concentration of salts becomes more dilute, whereas dry periods will lead to increased salinity and conductivity values (Carr and Neary, 2006). It is noted that salinity and EC values are lower on November and December than other months. The reason for this is rainfall which causes dilution of salts. Based on figures 3.3 and 3.4; Electrical conductivity increases as salinity increases and vice versa.

Measured Dissolved oxygen values (6.23-8.21mg/l) are above recommended value of Indian standard (4mg/l). This suggests that the experimental sites were not experiencing any oxygen deficiency at that time. Water can hold more dissolved oxygen (DO saturation) at low temperatures than at high temperatures (ODEQ and ODF, 1996). The decay of organic matter can consume oxygen; therefore the presence of excessive amounts of decaying organic matter can result in low levels of dissolved oxygen (DEFA, 2007).



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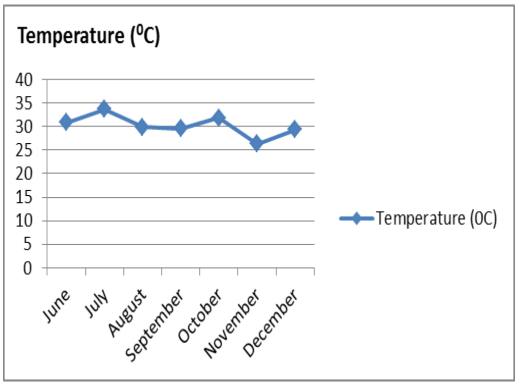
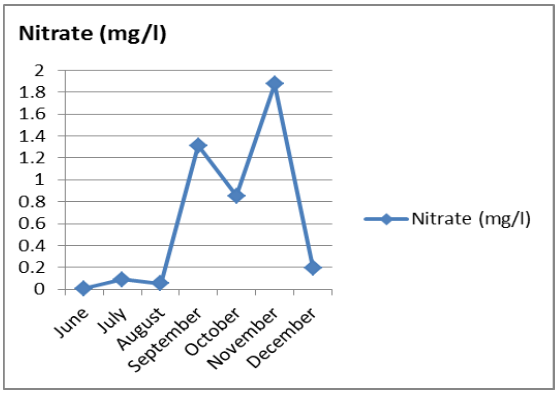


The temperature of recreational water bodies should be in the range of 16–34°C (NHMRC, 2008) and measured values (25.6-33.9^{0}C) were within those limits. Temperature, or changes in temperature, is important in the regulation or triggering of many physiological processes in marine organisms. Anthropogenic sources which may influence water temperature in the marine environment are usually related to the discharge of cooling water from power stations and certain industries (DWAF, 1995).

Comparison of Nitrate and Phosphate concentration values with the standard values and its monthly variation

Recorded nitrate and phosphate value ranges were 0- 2.8mg/l and 0.13-4.51mg/l with the mean values of 0.63 and 1.36mg/l respectively. When compare the mean values with the recommended values of Malaysia (Nitrate-60µg/l and Phosphate-75µg/l); these values exceed the recommended values. Substances such as fertilizers and detergents carried by canal, sewage and storm water runoff during rainy season may be reasons which increase nitrate and phosphate concentrations in water. Also Amarasiri (2007) stated that the large amount of nitrogenous fertilizers has contributed to increased high levels of nitrate in water in many countries. In the marine environment nitrogen pollution is largely derived from agricultural fertilizers and also from the combustion of fossil fuels, whilst phosphorus pollution is linked primarily to waste water treatment and detergents (DEFA, 2009).



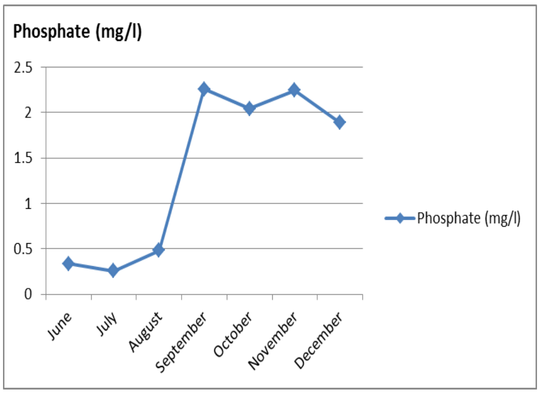


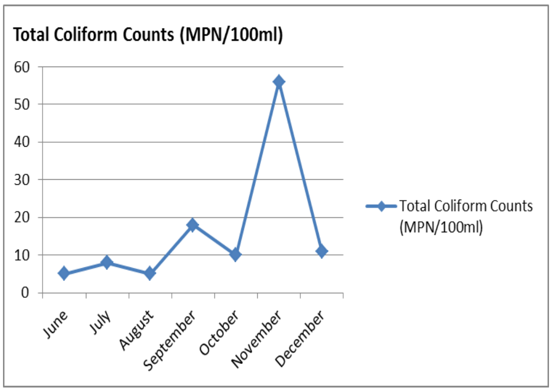
Figure 3.7 and 3.8: Monthly variation in Nitrate and Phosphate level

According to the figure 3.7 and 3.8; nitrate and phosphate values are higher from September to December than June to August. The major reason for this is rainfall during September to December. During rainy season; large quantities of nutrients released into sea water due to surface runoff, discharge from sewage and canal located closer bathing site.

The major sources of elevated nutrients to coastal waters are typically from agricultural waste and hotel wastes (e.g. fertilizers, detergents). Further, large quantities of nutrients released into the coastal water through the sewage waste water (Danulat *et al.,* 2002). At elevated levels in surface water, nutrients may cause algal outbreaks in rivers, lakes and oceans.

Monthly Variation in Total Coliform and *Escherichia coli* counts

Total Coliform and *Escherichia coli* counts were ranges between 0-93 and 0-40MPN/100ml with the mean value of 16 and 6MPN/100ml respectively. Measured *Escherichia coli* counts are within Indian standard value (100MPN/100ml) and total Coliform counts are within threshold limit of Japan (1000MPN/100ml). So, based on the results; Pasikudah beach is suitable for the recreational activities.



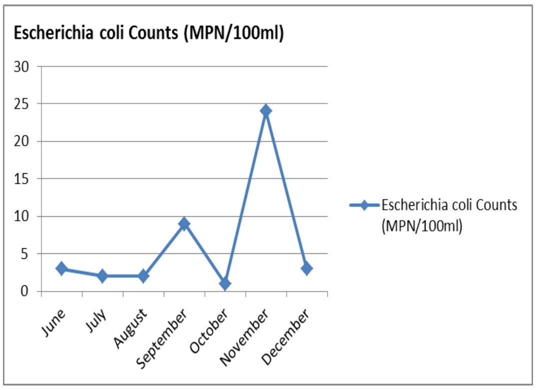


Figure 3.9 and 4.0: Monthly variation in Total Coliform and Escherichia coli counts

According to the figure 3.9 and 4.0; total Coliform and *Escherichia coli* counts are higher from September to December than June to August. Because, during rainy season; animal and domestic wastes are released into sea water due to surface runoff, discharge from sewage and canal located closer bathing site. The main sources of *Escherichia coli* are untreated or partially treated animal and domestic wastes and also sewage from coastal premises including hotels and restaurants (DOE, 2010).

There are a number of factors that can influence the microbiological quality of a recreational water body at any given time. These can include the type and periodicity of contamination events (both point and non-point sources), the time of day, recent weather conditions, the number of users frequenting the swimming area and the physical characteristics of the area itself (Health Canada, 2012). In some instances, the microbial quality of recreational water may be strongly influenced by factors such as rainfall within the catchment, potentially leading to short periods of elevated faecal pollution (NHMRC, 2008).

Conclusions and suggestions

Conclusions

Following conclusions can be obtained from this research study.

- Marine water quality results of Pasikudah beach revealed that, average pH (8.03), Turbidity (9.94NTU) and temperature (30.2 ^{0}C) were within the marine water quality standards for recreational beaches. Measured value range for Electrical Conductivity (EC) and salinity were 46.46- 58.16mS/cm and 27.63- 33.52PSU respectively. Electrical conductivity and salinity had positive correlation and It was noted that salinity and EC values were lower on November and December than other months. The reason for this is rainfall which causes dilution of salts.
- Measured Dissolved oxygen values (6.23-8.21mg/l) were above minimum required level (4mg/l). This suggests that the experimental sites were not experiencing any oxygen deficiency at that time. Recorded nitrate and phosphate value ranges were 0- 2.8mg/l and 0.13- 4.51mg/l with the mean values of 0.63 and 1.36mg/l respectively. When compare the mean values with the standard values (Nitrate-60µg/l and Phosphate-75µg/l); these values exceeded. Substances such as fertilizers and detergents carried by canal closer to bathing site, sewage and storm water runoff during rainy season may be reasons which increase nitrate and phosphate concentrations in water.
- Total Coliform and *Escherichia coli* counts were ranges between 0-93 and 0-40MPN/100ml with the mean value of 16 and 6MPN/100ml respectively and measured *values we*re within standard values. So, based on overall results; Pasikudah beach is suitable for the recreational activities.

Suggestions

- More frequent (daily/weekly/monthly) and long term monitoring is very essential for this important recreational site to identify issues and take remedial actions.
- Improve the public health through sanitary facilities such as providing latrine facilities and establishment of waste collection bin closer to beach area. Further, waste water discharges (sewage, hotel discharges) should be treated before discharge into sea.
- Awareness programs about coastal pollution should be conducted among coastal communities including fishermen, school children, hotel owners and tourist association. Information on the quality of the water should be communicated to the user through the use of posted signs. Signs should be used to warn users when the water is unsafe for recreational use as well as to communicate when the water is safe for use.

- Proper coordination should be created among government and nongovernmental organizations to minimize the effect of pollution from the land based activities. Regulation should be implemented to minimize the pollution from tourism and public activities. In Sri Lanka, there are no marine water quality standards for recreational sites until now. Marine water quality standards for recreational sites should be established using coastal water quality monitoring data and expert views and comments.

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