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Original Research Article

Coastal Water Recreation and Public Health of South India – A Case Study in Varkala Beach

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A B S T R A C T

Keywords

Coastal tourism; bacteriological parameters; Varkala.

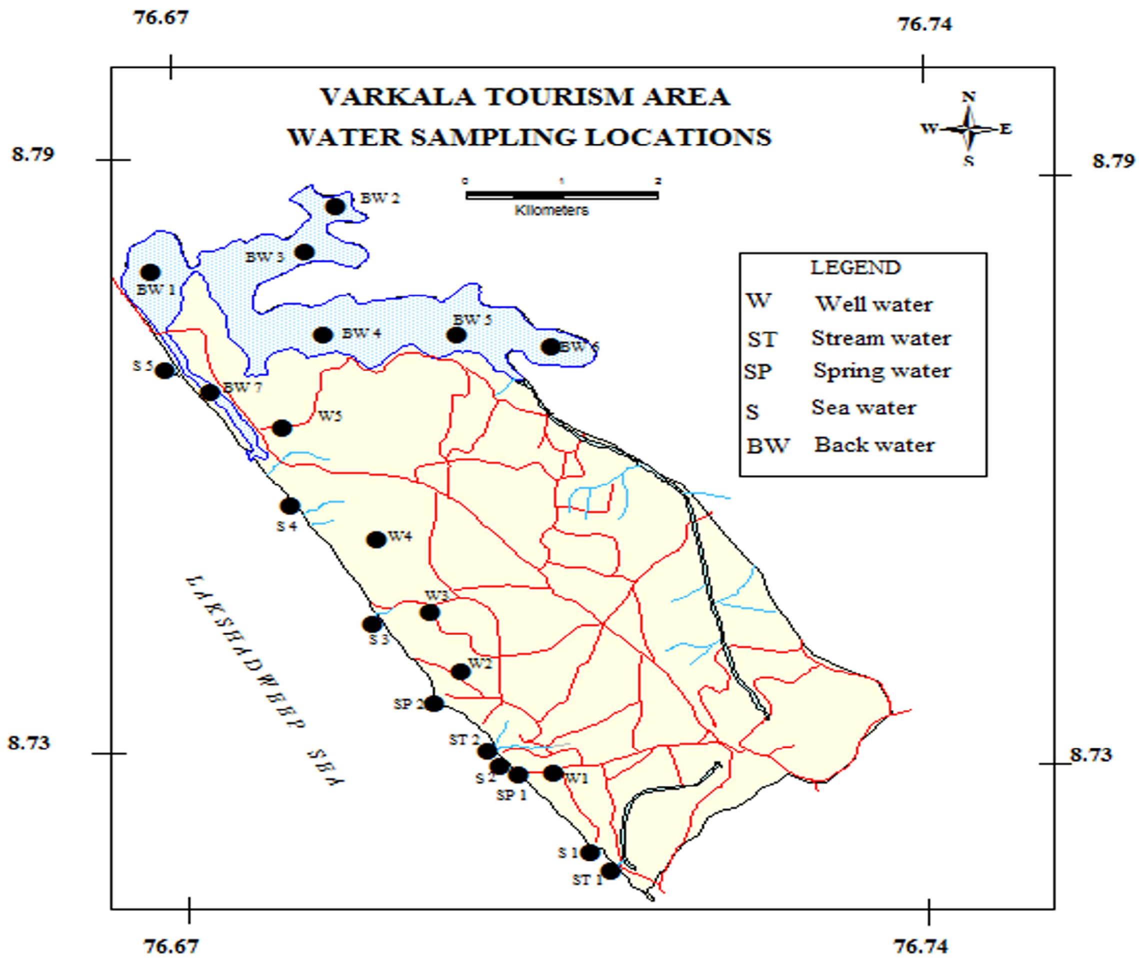
Tourism, one of the fastest growing industries all over the world plays a major role in many countries economy and becomes the greatest contributor of employment. The industry also has some negative impacts on global ecosystems. The study area – Varkala is in the south west coast of India with beautiful pocket beaches attracting many numbers of people. Unlike in developed countries there are no strict rules to control the number of tourists or to test the quality of recreational water. The present study concentrates on enteric microbes associated with recreational water, discusses how it affect public health and the possible options to the developing world for sustainable development.

Introduction

Among the different impacts of coastal tourism on the environment, the effect of tourism on public health has special importance. The increase in population during the peak tourism season results usually in an increase in the amount of waste water. Unavailability of necessary infrastructure for waste treatment makes the sea polluted, causing serious health problems. In its most recent report on waterborne disease and outbreaks associated with recreational water, the Center for Disease Control and Prevention concluded that the incidence of infections associated with recreational water use has steadily increased over the past several decades (Yoder *et al*., 2008).

Many enteric pathogens are transmitted when drinking water is contaminated water with faecal matter or by consumption of faecally contaminated food. In endemic situations with poor sanitation and hygiene, the attributable risk due to water may be difficult to determine because of the risks from many other routes of transmission. Different classes of organisms have specific attributes, such as size and charge, which determine their movement and survival in the aquatic environment and their

Figure.1 Map showing the sampling points



susceptibility to various water and wastewater treatment processes. Knowledge of these attributes can aid in the design of effective barriers or control strategies. The study area Varkala, a coastal town in south India is a fast developing tourism destination, which is increasingly attracting many tourists all over the world. The major tourism attractions are beautiful beaches, back waters and sea foods. The streams into the sea carries untreated sewage from the nearby town and tourists amenities along the coasts are principal pollution sources and are becoming serious threat to recreational activities by affecting public health.

Materials and Methods

Samples were collected 500 ml of sterilised sample containers in accordance with the standard procedures recommended in Standard Methods (1995) in tourism pre tourism and post tourism seasons (Fig.1). The detection for the presence of all intestinal pathogens as a routine examination could be tedious and difficult to process. However, it is easy to demonstrate the presence of some of the non pathogenic intestinal organisms such as *E. coli* and *Streptococcus faecalis*. These organisms were always found in the intestine, if these organisms are detected in water, it could be assumed that the water had been contaminated with faecal material. These organisms are called as indicator organisms (Kannan, 1996).

Most Probable Number Method

The bacteriological contaminations of the water samples were analysed by testing the Total Coliform and Faecal Coliform indicator bacteria. These were tested by the Most Probable Number Method at elevated temperature using EC Broth as the medium. 10 ml of the water samples (3 numbers) were inoculated into tubes containing 10 ml of double strength EC Broth.

The inoculated test tubes were then incubated at 35^0C and 44.5^0C for 24 hours, for the estimation of total coliform and faecal coliform. Gas production in the inverted Durham's tubes was considered as positive for the presence of total coliform and faecal coliforms. The number of positive tubes in each dilution was recorded and the MPN value for total coliform and faecal coliforms were determined from standard MPN table.

Analysis of Faecal Coliforms (FC)

Faecal coliform load of water sample was determined by three-tube dilution method (Multiple tube fermentation method) using lactose broth.

Analysis of Faecal Streptococci (FS)

Faecal streptococci load of the water sample was determined by three- tube dilution method (Multiple tube fermentation method) using Azide dextrose broth.

Morphological and cultural characteristics

The appearance of colonial growth on the surface of a solid medium, such as nutrient agar, is often very characteristic. Attention is paid to the diameter of the colonies, their outline, their elevation, their translucency (clear, translucent or opaque) and colour. Changes brought about in the medium (e.g. haemolysis in a blood agar medium) may also be significant. The range of conditions that support growth is characteristic of particular organisms. The ability or inability of the organism to grow aerobically or anaerobically or on media containing selective inhibitor factors (e.g., bile salt, specific antimicrobial agents or low or high pH) may also be of diagnostic significance.

Species that cannot be distinguished by morphology and cultural characters may exhibit metabolic differences that can be exploited. It is usual to test the ability of the organism to produce acidic and gaseous end products, when presented with individual carbohydrates as the sole carbon source. Other tests determine whether the bacteria produce particular end products (indole or hydrogen sulphide) when grown in suitable culture media and whether it possesses certain enzymes activities, such as oxidase, catalase, urease, gelatianse and lecithinase.

Microscopy and staining reactions of individual organisms serve as preliminary criteria to place an unknown species in its appropriate biological group. A Gram stain smear suffers to show the Gram reaction, size, shape and grouping of the bacteria. Carbohydrate Fermentation Tests to determine the ability of an organism to ferment (degrade) a specific carbohydrate incorporated in a basal medium and produce acid or acid with visible gas, Catalase – Peroxidase Tests to test for the presence of the enzymes catalase or peroxidase. Citrate Test to determine the organism is capable of utilizing citrate for metabolism and growth resulting alkalinity. Indole Test to determine the ability of an organism to split indole, Methyl Red Test to test the ability of an organism to produce and maintain stable acid end products from glucose fermentation and to overcome the buffering capacity of the system. This is a quantitative test for acid production (pH determination); some organisms produce more acids than others. Voges-Proskauer Test to determine the ability of some organisms to produce neutral end products from glucose fermentation. Triple Sugar Iron Agar Tests to determine the ability of an organism to attach a specific carbohydrate incorporated in a basal growth medium, with or without the production of gas along with the determination of possible hydrogen sulphide production, Motility Test to determine whether an organism is motile or non motile, Oxidation-Fermentation Test to determine the oxidative or fermentative metabolism of a carbohydrates. The above tests are performed to find out the various pathogenic organisms in the samples of the study area.

Results and discussion

Faecal coliform

In streams, the faecal coliforms was >2400 MPN/100 ml during both the pre tourism and post tourism seasons. The minimum was recorded during the tourism season (ST1 and ST2). In springs, the maximum faecal coliform reported was 240 MPN/100 ml (SP 2). This stood same in all the three seasons studied (Table1). The least value obtained was 23 MPN/100 ml during the tourism season (SP 1).

Among the marine systems studied, FC values ranged from 240 to >2400 MPN/100 ml. The least value was recorded from S 3, S 4 and S 5 during both the pre tourism and post tourism seasons. The maximum value was recorded from S 2 throughout the seasons.

The back water systems showed the FC value ranging from 23 to 460 MPN/100 ml. The least value was recorded from BW 2 during both the pre tourism and post tourism seasons. The maximum value was recorded from BW 1, BW 3 and BW 4 during the tourism season (Table 1).

Faecal streptococci

In streams, the faecal streptococci ranged from 210 to >2400 MPN/100 ml during both the pre tourism and post tourism seasons. The least value was recorded from ST2 and the maximum value from ST 1. The FC value in the tourism period remained the same for both sites. In springs, the maximum faecal streptococcus reported was 460 MPN/100 ml (SP 2) during the post tourism season (Table 1). The least values were recorded during the tourism season.

Among the marine systems studied, FS values ranged from 23 to 150 MPN/100 ml. The least value was recorded from S 4 and S 5 for all the seasons considered. The maximum value was recorded from two sites, S 1 during the tourism period and S 3 during the post tourism season.

The back water systems showed the FS value ranging from 23 to 43 MPN/100 ml. The least value was recorded from BW 1 all the seasons considered. The maximum value was recorded from BW 4 and BW 5 during the tourism season.

Colony count

In streams, the colony count ranged from 8000 to 35000 per ml. The least value was recorded from ST 1 during the tourism season and the maximum value from ST 2 during the post tourism season. In springs, the maximum colony count reported was 1400 per ml (SP 1) during the tourism season (Table 1). The least values (240/ml) were recorded during the pre and post tourism season.

Among the marine systems studied, colony count values ranged from 600 to 7500/ml. The least value was recorded from S 4 during the post tourism season. The maximum value was recorded from S 1 during the post tourism season.

The back water systems showed the colony count ranging from 1000 to 5400/ml. The least value was recorded from BW 3 during the pre tourism season. The maximum value was recorded from BW 1 during the tourism season. The colony count was high in all the sampling sites of backwaters during the tourism season.

Bacterial Diversity

The bacterial species observed in the study area during the period of study were *V. parahemolyticus, V. fluvialis / V.cholera, E. coli, Enterobacter aerogenes, Enterococcus and Klebsiella pneumonia*. The seasonal variations of organisms based on tourism were shown in the table 2. Solid waste being dumped in open spaces and the sewage discharged through the streams emptying in the beaches (Chilakkur - Eanikkal area and the Papanasam) pollute the beaches. The water quality analysis indicates that the streams in touch with the sea carry heavy load of pollutants into the sea. Microbial analysis indicates the presence of different types of enteric pathogens in stream water and coastal water. The classification of water-related diseases provides a valuable framework for understanding the relationship between infectious disease transmission and water (Bradley, 1977). This classification system facilities the planning of effective prevention and control measures for a variety of water-related diseases, depending on the type of agent and transmission route involved. Bivalve molluscans shellfish serve as vehicles of enteric disease transmission because of their ability to concentrate enteric organism from faecally contaminated water in their tissue. Numerous outbreaks have been attributed to the consumption of raw or undercooked oysters, clams and mussels (Morse *et al*., 1986). Many pathogens, including hepatitis A and E viruses, human caliciviruses (HuCV), Norwalk-like viruses (NLV), pathogenic *E. coli*, *S. enterica* serovar Typhi, and species of *Shigella*, *Vibrio*, *Pleisomonas* and *Aeromonas*, have been implicated in shellfish-borne disease (Hackney and Potter, 1994a; 1994b).

Shellfish and some species of fish may also serve as vehicles for algal toxins. Toxic species of *Gonyaulax* and *Gymnodinium* are concentrated by filter-feeding molluscs and can cause paralytic shellfish poisoning among shellfish consumers (Carmichael *et al*., 1985). Reef-feeding fish can concentrate toxic dinoflagellates of the genus Gambierdiscus, which cause ciguatera seafood poisoning in consumers (Carmichael *et al*., 1985). Prevention and control of waterborne diseases requires accurate and rapid methods to measure microbiological water quality and to identify and evaluate risk factors for waterborne diseases.

Table.1 Seasonal variation (Mean values) of bacteriological parameters in different water sources of Varkala

Site	Seasons	FC (MPN / 100 ml)	FS (MPN / 100 ml)	FC / FS Ratio	Colony Count/ml
ST 1	Pre tourism	>2400	>2400	0	13500
	Tourism	240	240	0	8000
	Post tourism	>2400	>2400	0	12500
ST 2	Pre tourism	>2400	210	11.43	14000
	Tourism	240	240	0	4400
	Post tourism	>2400	210	11.43	34000
SP1	Pre tourism	43	4	10.75	600
	Tourism	23	9	2.56	1400
	Post tourism	75	4	18.75	900
SP 2	Pre tourism	240	93	2.58	240
	Tourism	240	23	10.43	330
	Post tourism	240	460	0.52	240
S 1	Pre tourism	460	75	6.13	6500
	Tourism	1100	150	7.33	1320
	Post tourism	460	75	6.13	7500
S 2	Pre tourism	>2400	93	25.81	1600
	Tourism	>2400	23	104.35	1380
	Post tourism	>2400	93	25.81	1800
S 3	Pre tourism	240	93	2.58	1050
	Tourism	460	93	4.95	1200
	Post tourism	240	150	1.6	1250
S 4	Pre tourism	240	23	10.43	650
	Tourism	460	23	20	900
	Post tourism	240	23	10.43	600
S 5	Pre tourism	240	23	10.43	950
	Tourism	460	23	20	1100
	Post tourism	240	23	10.43	1040
BW 1	Pre tourism	93	23	4.04	1800
	Tourism	460	23	20	5400
	Post tourism	93	23	4.04	2000
BW 2	Pre tourism	23	23	0	2100
	Tourism	240	39	6.15	2200
	Post tourism	23	23	0	1200
BW 3	Pre tourism	93	23	4.04	1000
	Tourism	460	23	20	3300
	Post tourism	93	20	4.65	1400
BW 4	Pre tourism	43	39	1.1	3000
	Tourism	460	43	20	3100
	Post tourism	75	39	1.92	2100
BW 5	Pre tourism	93	23	4.04	2200
	Tourism	240	43	5.58	3100
	Post tourism	93	23	4.04	2000

Table.2 Seasonal variation of bacterial species in different water sources of Varkala

Site	Seasons	*V. parahemolyticus*	*V. cholera / V. fluvialis*	*E. coli*	*E. aerogenes*	*Enterococcus*	*K.pneumoniae*
ST 1	Pre tourism	*	*	*	*	*	*
	Tourism	*	*	*	*	*	-
	Post tourism	-	*	*	*	*	*
ST 2	Pre tourism	*	*	*	*	*	*
	Tourism	-	*	*	*	-	-
	Post tourism	*	*	*	*	*	*
SP1	Pre tourism	-	-	*	*	-	*
	Tourism	*	-	*	*	*	-
	Post tourism	*	-	*	*	*	*
SP 2	Pre tourism	*	-	*	*	*	*
	Tourism	-	*	*	*	-	*
	Post tourism	*	-	*	*	*	*
S 1	Pre tourism	*	*	*	*	*	*
	Tourism	-	*	-	-	-	-
	Post tourism	*	*	*	*	*	*
S 2	Pre tourism	*	-	*	-	-	*
	Tourism	-	*	-	-	-	-
	Post tourism	*	-	*	-	-	*
S 3	Pre tourism	*	*	*	*	-	*
	Tourism	*	*	-	-	-	-
	Post tourism	*	*	*	*	-	*
S 4	Pre tourism	*	*	*	*	*	*
	Tourism	*	*	-	-	*	*
	Post tourism	*	*	*	*	*	*
S 5	Pre tourism	*	*	*	-	-	*
	Tourism	*	*	-	-	-	-

	Post tourism	*	*	*	-	-	*
BW 1	Pre tourism	*	*	*	-	-	*
	Tourism	-	*	*	*	-	-
	Post tourism	*	*	*	-	-	*
BW 2	Pre tourism	*	-	*	-	-	*
	Tourism	*	*	*	*	*	*
	Post tourism	*	-	*	-	-	*
BW 3	Pre tourism	*	*	*	-	-	-
	Tourism	*	*	*	*	-	-
	Post tourism	*	*	*	-	-	-
BW 4	Pre tourism	*	*	*	-	-	-
	Tourism	*	*	*	*	*	*
	Post tourism	*	*	*	-	-	-
BW 5	Pre tourism	*	*	*	-	*	-
	Tourism	*	*	*	*	-	-
	Post tourism	*	*	*	-	-	-
(*) presence (-) absence							

The microbial contamination of the coastal water is mainly from the streams, analysis indicate there are different types of enteric pathogens exist both in stream water and coastal water. Bathers themselves are an important localized source of contamination leading to illness outbreaks (Craun *et al*., 2005). All swimmers release fecal organisms when they enter the water in a process called bather shedding (Mcdonald *et al*., 2008). Results from one study showed that bathers shed on the order of 600,000 colony-forming units, or cfu, per person of enterococci bacteria during the first 15 minutes of water contact (Elmir *et al*., 2007). Swimmers in sewage polluted water can contract any illness that is spread by fecal contact, including gastroenteritis, respiratory infection, ear and skin infections or stomach flu (inflammation of the stomach and the small intestine). Symptoms include vomiting, diarrhoea, stomach ache, nausea, headache, and fever. Another major problem that Varkala may face in the coming future is salt water intrusion to the fresh water wells because of the over exploitation of ground water by bore wells/tube wells for tourism purposes such as swimming pools and other amenities.

Recreational waters must be tested regularly, and the results must be measured against effective health standards. When waters do not meet these standards, authorities must promptly and clearly notify the public. The point sources of pollution through streams into the sea should be strictly controlled and discharge into the natural water body only after pre treatment. A BEACH Act, like other developed countries should implement by the local governments of other nations with recreational significance. Accelerate the timetable implementation of new standards to protect the public, and establishing testing methods that will enable public health officials to make prompt decisions about closing beaches and issuing advisories. Number of tourists should be limited within the carrying capacity helps sustainable development of the area.

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