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Microbiological and Physico-chemical Study in Coastal Water of Port Goa, India

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ABSTRACT

Goa is a state on the South Western coast of India within the coastal region known as the Konkan. It is bounded by Maharashtra to the north and Karnataka to the east and south, with the Arabian Sea forming its Western coast. Goa is visited by large numbers of international and domestic tourists each year for its white sand beaches, nightlife, places of worship and world heritage architecture. It has rich flora and fauna, owing to its location on the Western Ghats range, a biodiversity hotspot. Baina and Grandmother's hole beach are two smaller beaches around Vasco da Gama the largest city in the state of Goa on the west coast of India. Baga Beach is a popular beach and tourist destination in North Goa. Calangute is a town in North Goa, famous for its beach. The beach is the largest in North Goa and visited by thousands of domestic and international tourists alike. The microbiological and Physio-chemical study of 4 different coastal beaches Baga, Calangute, Baina ad Grandmother's hole beach located in Goa, India, were monitored. 2 out of 4 beaches showed the poorest water quality so the highest level of Total Coliform and Faecal Coliform these are Baina and Grandmother's hole beach. This could be due to the less number of people visiting the beach and high number of animal population living there. The poorest water quality is especially in the urban discharged points and in the area close to them.

Key words *Total Coliform, Faecal Coliform, Coastal water, urban waste management, physic-chemical parameters.*

India has a long coastline of over 8000 km with associated continental shelf of 0.5 million km2 and an Exclusive Economic Zone of 2.02 million km2. The coastal zone of the country with its wetlands, lagoons, mangroves, sea-grass beds, coral reefs and shallow bays, creeks and estuaries is rich in natural resources. Unfortunately, much of this wealth is often exploited in an indiscriminate or ill-planned manner resulting in rapid resource depletion and irreversible environmental degradation. Major driving forces for coastal degradation include (a) high rate of growth in population leading to reclamation of coastal areas and release of wastes, (b) over-fishing due to lack of alternative livelihoods, (c) large commercial enterprises aiming at quick profit at the cost of sustainability and their insensitivity to the interests of local inhabitants, (d) ignorance about management of resource sustainability among stake holders and policy makers, (e) lack of understanding of environmental significance and importance of coastal habitats, and (f) inadequate enforcement of environmental rules and regulations [54]. Goa is a state on the South Western coast of India within the coastal region known as the Konkan. It is bounded by Maharashtra to the north and Karnataka to the east and south, with the Arabian Sea forming its Western coast. It is India's smallest state by area and the fourth smallest by population. Goa has the highest GDP per capita among all Indian states, [1] that is two and a half times that of the country [2]. It was ranked the 'best placed State' by the "Eleventh Finance Commission" for its infrastructure and ranked on top for the 'best quality of life' in India by the National Commission on Population based on the 12 Indicators [2]. Goa is visited by large numbers of international and domestic tourists each year for its white sand beaches, nightlife, places of worship and world heritage architecture. It has rich flora and fauna, owing to its location on the Western Ghats range, a biodiversity hotspot. The state of Goa, in India, is famous for its beaches and places of worship, and tourism is its primary industry. Tourism is generally focused on the coastal areas of Goa, with decreased tourist activity inland. Foreign tourists, mostly from Europe, arrive in Goa in winter whilst the summer and monsoon seasons see a large number of Indian tourists. Goa handled 2.29% of all foreign tourist arrivals in the country in 2011.[3][4] This relatively small state is situated on the western coast of India, between the borders of Maharashtra and Karnataka and is better known to the world as a former Portuguese enclave on Indian soil. Tourism is said to be the backbone of Goa's economy [5]. Goa's beaches cover about 125 kilometres (78 mi) of its coastline. These beaches are divided into North and South Goa. North Goa is more commercial and touristy with an abundance of mostly low and medium budget tourist accommodations; whereas South Goa is where most higher–end hotels and private beaches are located. The further north or south you go, the more isolated the beaches get. Some of the more popular beaches are Colva, Calangute, Baga and Anjuna. These beaches are lined with shacks that provide fresh sea food and drinks. Some shacks arrange special events to attract more customers.

Baga a seaside town in Bardez, Goa, India. It comes under the jurisdiction of Calangute, which is 2 km south. Baga is known for its popular beach and Baga Creek. It is visited by thousands of tourists annually. Baga Beach is a popular beach and tourist destination in North Goa. [6][7] Baga is located at the north end of the contiguous beach stretch that starts from Sinquerim, Candolim, leads to Calangute and then to Baga. The beach contains rows of

shacks and fishing boats, and at high tide the beach is narrow.[8] The beach is named after the Baga Creek, which empties into the Arabian Sea at the north end of the beach.[9] Baga Beach is also famous for water sports such as parasailing and banana rides, and dolphin cruises. In Baga Beach, new parking has been constructed for around 800 cars or more, and there is baga Creek Bridge which connects northern part like Arpora, Anjuna etc.

Calangute beach is the largest in North Goa and visited by thousands of domestic and international tourists alike. The peak tourist season is during Christmas and New Year, and during the summer in May. During the monsoon season, from June through September, the sea can be rough and swimming is prohibited. The beach offers water sport activities like parasailing and water skiing, among others [10].

The coastal area is low lying with heights of not more than 3.0 m above sea level and are generally covered by fresh water swamp, mangrove swamp, lagoon mashes, tidal channels, beach ridges and sand bars [14]. The term pollution generally refers to the alteration of the natural physico-chemical characteristics of an entity, medium or matter as a result of the presence of substances or compounds that are not supposed to be present in it or that are present in quantities and qualities that would alter the natural balance of the particular entity, medium or matter. Consequently, we can classify pollution in terms of where or medium of occurrence, such as water or aquatic pollution (marine, brackish or fresh water pollution), atmospheric pollution and soil/land pollution. Furthermore, pollution can be classified in terms of the type of the causative matter or compound, such as Chemical pollution, Noise pollution, air pollution, Agrochemical pollution, and Industrial and Domestic effluent pollution to mention but a few [15, 16]. In the case of west coast beaches, there are wastewater pipe lines discharge wastewater including sewage from hotels and houses directly into the sea. These discharges lead to degradation of the marine water quality causing significant negative impacts on marine ecosystem. Coastal waters have traditionally been considered as the ultimate sink for the by-products of human activities. In the recent past, expanding human population, industrialization, intensive agricultural practices and discharges of massive amount of wastewater into the ocean have resulted in deterioration of water quality [16]. Estuarine water will be particularly vulnerable to pollution due to the enclosed nature of the system and the subsequent accumulation of pollutants. It has been estimated that 70–80% of marine debris comes from land-based sources [114]. Heavy rains can cause sewage overflows, thus, by passing sewage treatment facilities, increasing surface water runoff directly influencing microbiological water quality. Discharges may be regular, through long and short sea outfalls and irregular through storm water and overflow outfalls, and unregulated private discharges. Due to the severe anthropogenic activity, the nutrients / Physio-chemical and microbial load, and trace metals levels were drastically fluctuated. Besides the marine micro biota, seawater and sediments can contain a significant nonindigenous micro biota composed by bacteria, virus and protozoan that are discharged to the environment from domestic sewage and urban drainage water [12]. The presence of such microorganisms in recreational seawater, sediments and beach sands affect the quality of these habitats, leading to high risk of beachgoer's health due to waterborne and other illness, as well as to the high resistance that can be showed by these microorganisms to several antimicrobial agents such as antibiotics [17]. Arabian coastal waters are widely used for a range of recreational activities, such as bathing, sailing, boating, etc. Maintaining and protecting the quality of this recreational water is therefore an important environmental health and resource management issue [21]. All the guidelines for assessing the public health risk of using recreational waters have been largely based on microbiological faecal indicator counts. In very functional way the pollution problem becomes even more worrying because, for different reasons, are requested also the physical, chemical and biological parameters standards of the waters [18, 19]. These beaches are located near urban areas and some beaches are located near stream discharges. Based on this we may say that in the Goa coastal water are identified these sources of the pollution, from: the portal activity, that even though completed with an aquarium, has a relation with the beach as a whole, due to the mixture of the water column by contributing mainly in pollution with heavy metals and hydrocarbons the beach through sewage waters, diffused and also point ones agriculture activities/ livestock that are particularly exercised in the lowland area [20]. Coastal marine environments are highly vulnerable to anthropogenic pollution from municipal sewage, industrial effluents as well as agriculture run- off and river discharges [26, 30, 48]. Faecal contamination not only impairs water quality but also potentiates human health risks [15, 28]. In urbanized areas, possibly sources of faecal pollution can include deficient sewage treatment and leaks due to wastewater treatment plant outflows [22, 23, 24]. Many coastal beaches are located near urban areas, others near river discharges, with input from agricultural and industrial wastes, so that potential risks of contamination may exist, whenever sewage treatment is not effective [25, 23]. Therefore regular monitoring of the quality of coastal waters has been suggested [26, 27], employing different sampling strategies, according to the specific characteristics of the recreational area in terms of physical-chemical and microbiological parameters [28, 29].

The faecal pollution of coastal environments may involve health risks leading to human exposure to pathogenic organisms, such as protozoa, bacteria and virus [30, 31, 32]. The health risk of infectious diseases transmitted by water can be measured by detection the universal microorganisms indicators of faecal contamination, the coliforms bacteria and faecal streptococci [30].These

indicators provide information about faecal discharges that may affect the local biota and water use [33]. Water contaminated by human or animal excreta may contain a range of pathogenic (disease- causing) micro-organisms, such as viruses, bacteria and protozoa. These organisms may pose a health hazard when the water is used for recreational activities such as swimming and other high-contact water sports. In these activities there is a reasonable risk that water will be swallowed, inhaled [34], or come in contact with ears, nasal passages, mucous membranes or cuts in the skin, allowing pathogens to enter the body. Indicator bacteria, including total coliform (TC), faecal coliform (FC) and faecal streptococci (FS), have been used and accepted in water quality studies to assess the level of faecal contamination in water bodies [35]. The presence of these organisms has also been used to estimate the potential human health risks of other pathogenic organisms of faecal origin. The term "coliform" was coined to describe this group of enteric bacteria. Coliform is not a taxonomic classification but rather a working definition used to describe a group of Gram-negative, facultative anaerobic rod-shaped bacteria that ferments lactose to produce acid and gas within 48 h at 35°C. In 1914, the U.S. Public Health Service adopted the enumeration of coliforms as a more convenient standard of sanitary significance. A number of studies demonstrated that Enterococci were the group with higher resistance to environmental stress [37, 38, 39, 40]. They may therefore be more suitable as indicators of faecal contamination due to their higher survival in water and their inability of multiplying in polluted waters [41]. Coliforms were easy to detect, their association with faecal contamination was questionable because some coliforms are found naturally in environmental samples [42, 43]. This led to the introduction of the faecal coliforms as an indicator of contamination. The faecal coliform group consists mostly of E. coli but some other enteric such as Klebsiella can also ferment lactose at these temperatures and therefore, be considered as faecal coliforms [44, 45]. The inclusion of Klebsiella spp. in the working definition of faecal coliforms diminished the correlation of this group with faecal contamination. As a result, E. coli has reemerged as an indicator, partly facilitated by the introduction of newer methods that can rapidly identify E. coli. Sewage effluents contain a wide range of human enteric pathogens which may pose a health hazard to the exposed human population when they are discharged into natural waters [46, 47]. Therefore, microbiological criteria for water quality have been directed towards protection of consumer and bathers from possible microbial pollution, which may cause public health hazards [48]. In recent years, the human interference through urbanization has grave impact on the microbial population of coastal water of the Arabian Sea. Coastal water generally contains both pathogenic and non-pathogenic microbes derive from river run off, sewage, industrial effluents, agricultural activities, wild life and indigenous microorganisms. These pathogens can create health hazard to bathers and consumers when an infective dose of pathogen colonizes a suitable growth site in the body and leads to a disease [49, 50].

The present study consists of the microbial population (total viable count, total coliforms and faecal coliforms) from coastal water of Goa. Attempts have been made to establish their relationship with some physic-chemical parameters [51]. The aim of the present study was to evaluate the microbiological quality of coastal waters in four different beaches in the west coast of Goa, India, located near populated areas, in different times of the year, based on the total and faecal coliform counts, as well as on the physic-chemical parameters. The influence of environmental parameters on the indicator values and their significance for the evaluation of the quality of waters is discussed.

MATERIALS AND METHODS

Sampling

The sea water from four different places in Goa coast were collected during January 2018 for microbiological (pollution indicators and pathogenic bacteria), and Physio-chemical analysis. The sampling sites were Baga (S1), Calangute (S2), Baina (S3) and Grandmother's hole beach (S4). The sampling sites were chosen based on the massive discharge of pollutants into the coastal zone without any sort of treatment and on the and on the number of peoples visiting there and those are an important coastal areas and harbours in the Goa coastal line. The sea water samples were collected from 0 to 30 cm below the surface [55, 56].

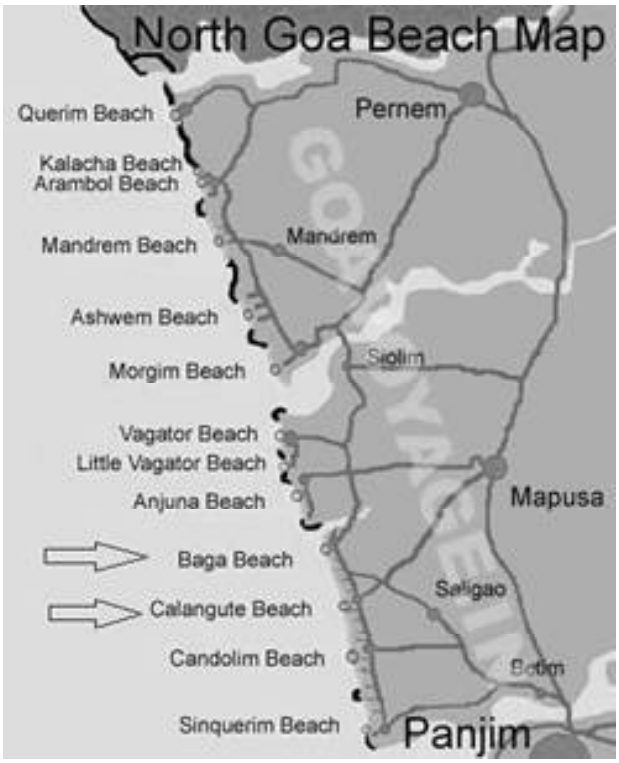


Fig 1. Sampling site 1 and 2

Fig 2. Pictures of Baga beach (S1)

Fig 3. Pictures of Calangute beach (S2)

Fig 4. Picture of Baina beach (S3)

Fig 5. Pictures of Grandmother's hole beach (S4)

The water samples were collected with a sterile container and each location and stored in ice box at 4! and were transported into laboratory.

Microbiological Parameter

Water samples for microbiological analysis are collected from surface and transferred into sterile glass bottles and transported into freezer. Samples are serially diluted, surface plated in duplicate in appropriate media before microbial analysis. Total coliforms (TC), faecal coliform (FC) are enumerated to assess the water quality. The media used for the growth of different groups of microorganisms are Nutrient Agar. Nutrient Agar plates are

incubated at 28°C and counted after 24 hours and 48 hours. FC plates are incubated at 44.5°C and counted after 48 hours. All other plates are incubated at 37°C and counted after 48 hours.

Physio-chemical Analysis

The Physio-chemical parameters like pH, alkalinity, chloride, hardness (calcium, magnesium) dissolved oxygen (DO) [58] and biochemical oxygen demand (BOD) [57] was determined.

RESULTS AND DISCUSSION

Table 1. Primary Water Quality Criteria for Class SW-II Waters (For Bathing, Contact Water Sports and Commercial Fishing, Source: As per CPCB)

Sl. No.	Parameters	Standards
1	Total coliform	100CFU/mL
2	Faecal coliform	100CFU/mL
3	Dissolved oxygen	5mg/mL
4	Biochemical oxygen demand	3mg/mL
5	pH	6.5 to 8.5

Table 2. Classification of water on the basis of total hardness [59]

Total hardness	Nature of water
0-60	Soft
61-120	Moderate
121-180	Hard
>181	Very hard

Table 3. Marine water quality standards (Indian and WHO) [60]

Sl. No.	Parameters	Acceptable	Maximum
1	Calcium hardness	75	200
2	Magnesium hardness	30	100
3	Chloride	250 ppm	1000

Microbiological parameters

Table 4. Variations of TC and FC in different samples (CFU/ml)

Samples	Total coliform	Faecal coliform
S1	63.8	6.8
S2	110.5	10.1
S3	178.4	11.2
S4	135.7	10.8

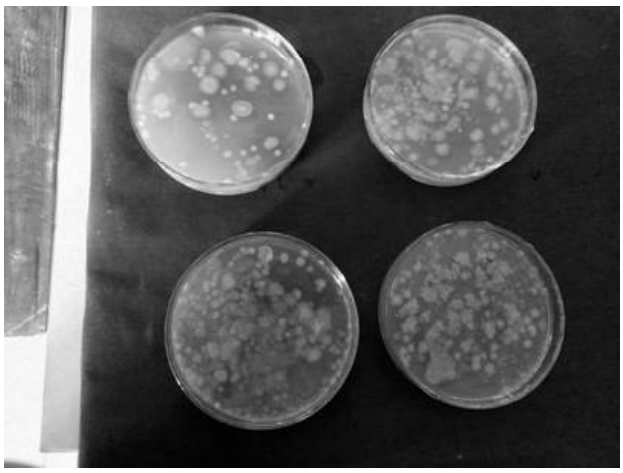


Fig 6. Bacterial colonies

During the investigation, it was observed that total coliform counts are recorded higher in sample 3 (Baina beach) 178.4CFU/ml and then slightly decreased in sample 4 (Grandmother's hole beach) 135.7CFU/ml followed by sample 2 and sample 1, 110.5CFU/ml and 63.8CFU/ml respectively. TC counts were comparatively higher than FC in every sample. FC count for sample 1, sample 2, sample 3, and sample 4 were recorded as 6.8CFU/ml, 9.4CFU/ml, 22.5CFU/ml, and 15.6CFU/ml respectively (Graph 1). It indicates the increase in the human induced activities near the coastal zone and sewage discharge sources. Faecal material from human, domestic animals (dogs, cattle, and horses), as well as birds/waterfowl (geese, gulls, and ducks), all lead to increases in bacterial/ pollution indicators loading in aquatic regions. Monitoring of physicochemical characteristics is not only decided the quality of water but the microbiological studies are also an important analysis for assessment of water quality [56].

Picture in Fig 7 was captured in February 2017 by a local photographer and it belongs to Baina beach our sample number 3 where highest counts of TC were recorded. Baina beach is the pooping zone for the locals living near it which makes it polluted. Sewage contamination in aquatic environments is commonly detected and quantified by

Fig 7. Source- Photo: JoeGoaUK [61]

enumerating the coliforms bacterial groups [62].

Physio-chemical parameters

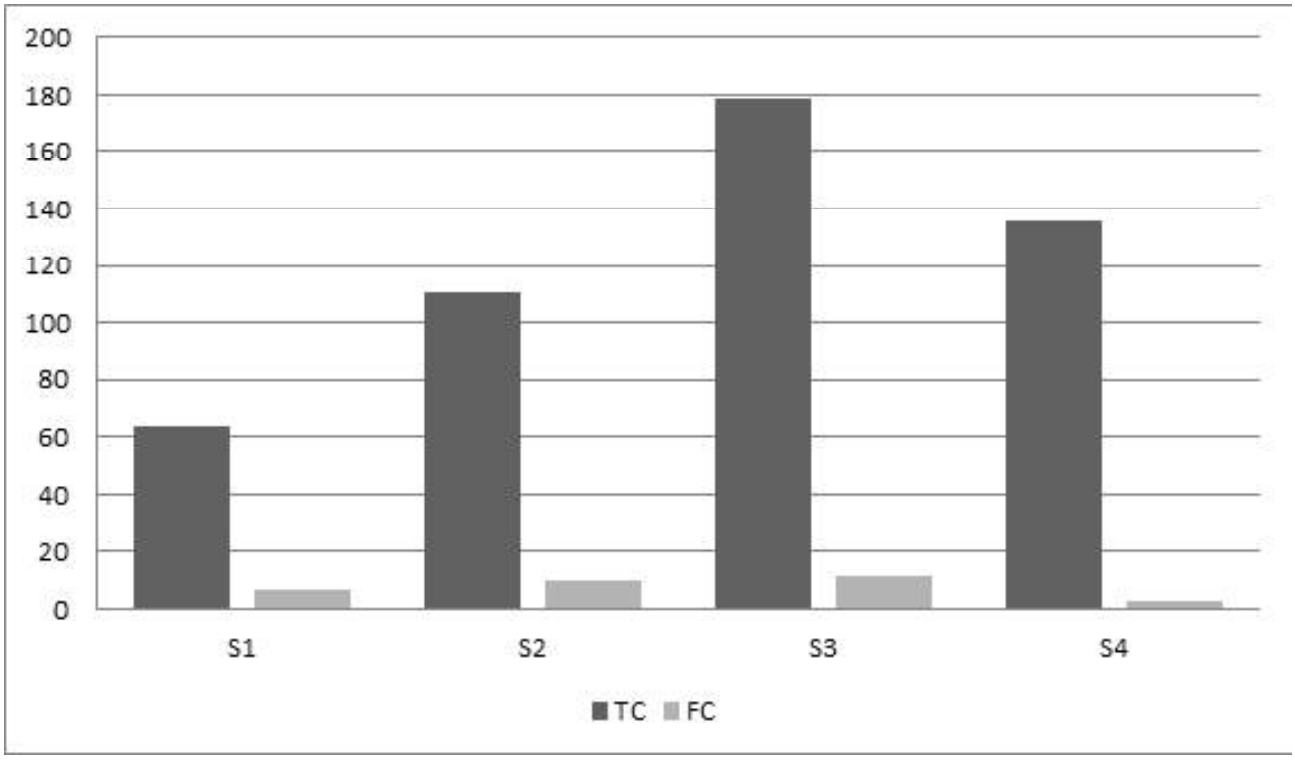
In Physio-chemical analysis, pH of sample 1, sample 2, sample 3, and sample 4 was recorded as 9.5, 10.4, 11.2, and 10.8 respectively. Highest pH was recorded in sample 3 (Baina beach). In case of alkalinity, highest were also recorded in sample 3(120mg/L) followed by 118mg/l, 110mg/l, and 102mg/l from sample 4, sample 2, and sample 1 respectively. Highest concentration of chloride was found in sample 4 i.e. 22962.6mg/l (Graph 2). Alkalinity and pH are two interdependent parameters; here in sample 3 pH is 11.2 that is maximum in all of the samples whereas in alkalinity, sample 3 has also the highest value that is 120mg/L highest among all.

In sample 2 maximum total hardness was recorded i.e. 69046mg/L and minimum was recorded in sample 4 i.e. 6190.4mh/L where number of people visiting the beach is very low (Graph 3).

Calcium hardness was recorded in sample 1, sample 2, sample 3, and sample 4 as 1000mh/L, 700mg/L, 1600mg/L, and 1200mg/L respectively. Sample 3 contains highest concentrations of calcium ions. Whereas in case of magnesium hardness it was found that sample 2 has the maximum magnesium hardness i.e. 833.8mg/L followed by sample 1, sample 3, and sample 4 i.e. 158.6mg/L, 117.5mg/L, and 2.8mg/L respectively (Graph 4). It is usually caused by the presence of calcium sulphate/calcium chloride and/or magnesium sulphate/magnesium chloride in the water, which do not precipitate out as the temperature increases.

In graph 5, biochemical oxygen demand and dissolved oxygen demand of various samples is given. Here we can see that maximum BOD level is recorded in sample 3 which is highly polluted among all the samples in every parameter whether it is microbiological or Physio-chemical. BOD of sample 1, sample 2, sample 3, and sample 4 are 6.57mg/L, 6.72mg/L, 7.84mg/L, and 6.99mg/L respectively and in case of dissolved oxygen (DO) sample 1 has least value for DO which represents that sample 1 (i.e. 0.58mh/L) is least polluted among all of these because it has more tourist attraction value as compared to sample 3 and sample 4. Sample 3 and sample 4 are near the shore, which may indicate the influence of human settlements and mixing of untreated sewage. Therefore, a low BOD is an indicator of good quality water, while a high BOD indicates polluted water. Dissolved oxygen (DO) is consumed by bacteria when large amounts of organic matter from sewage or other discharges are present in the water. Biochemical Oxygen Demand is an important water quality parameter because it provides an index to assess the effect discharged wastewater will have on the receiving environment. When BOD levels are high, dissolved oxygen (DO) levels decrease because the oxygen that is available in the water is being consumed by the bacteria. Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive [63]. The increased human aggression in the form release of sewage and industrial wastes, dumping of solid waste garbage in the creeks caused stress on the ecosystem [64].

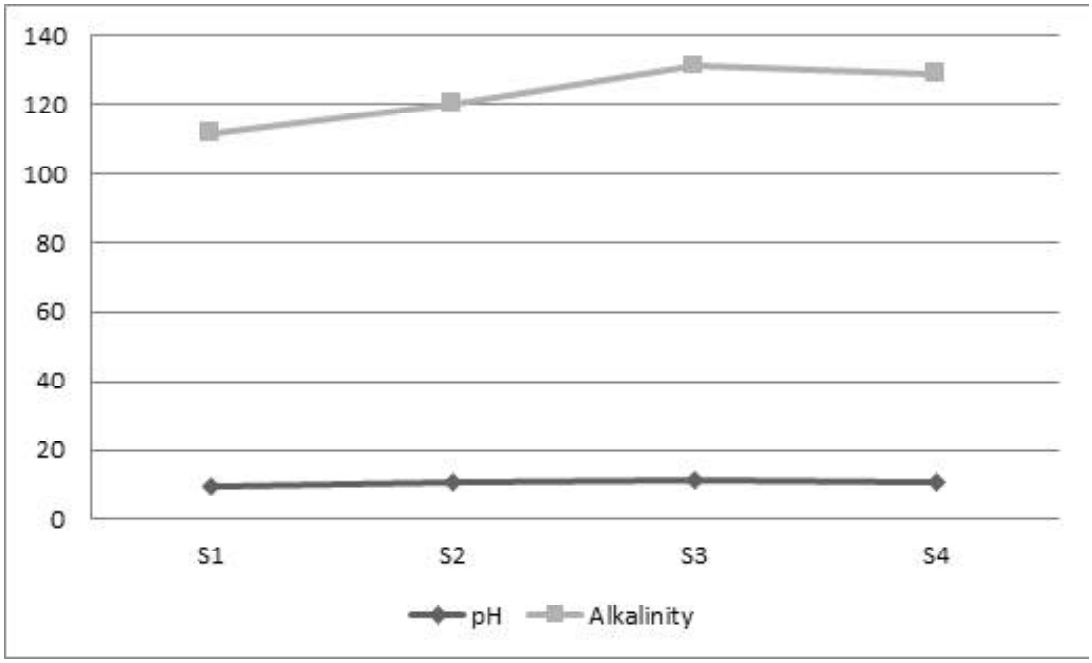
Sampling locations due to the accumulation of mass discharges of different waste materials into the coastal zone. In this study, the Physio-chemical, microbial parameter levels were high in the sea water and it can be classified



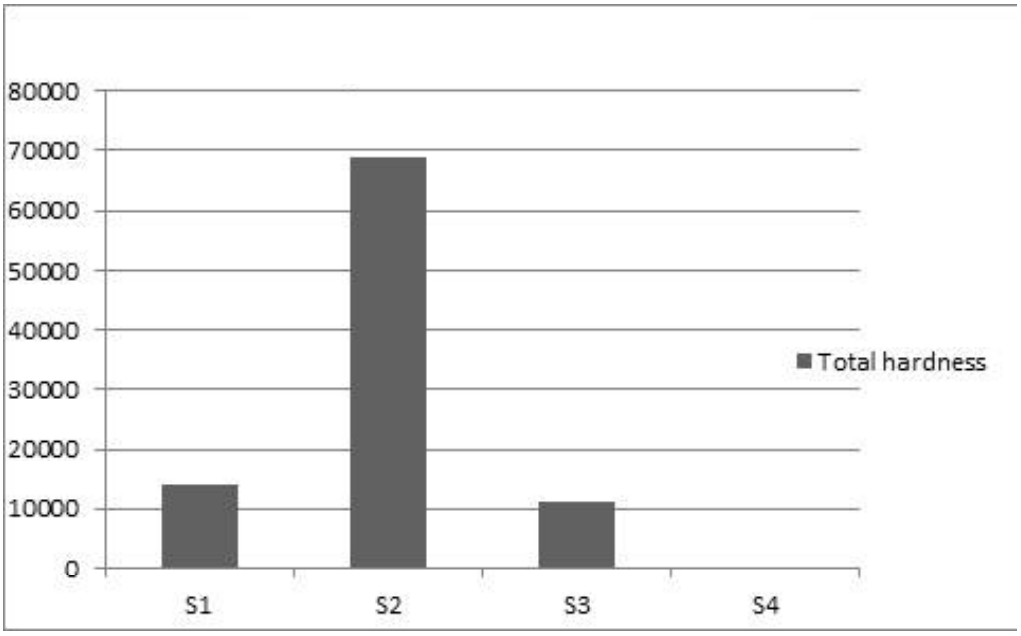
Graph 1. TC and FC counts in various samples

Table 5. Various Physio-chemical parameters in different samples

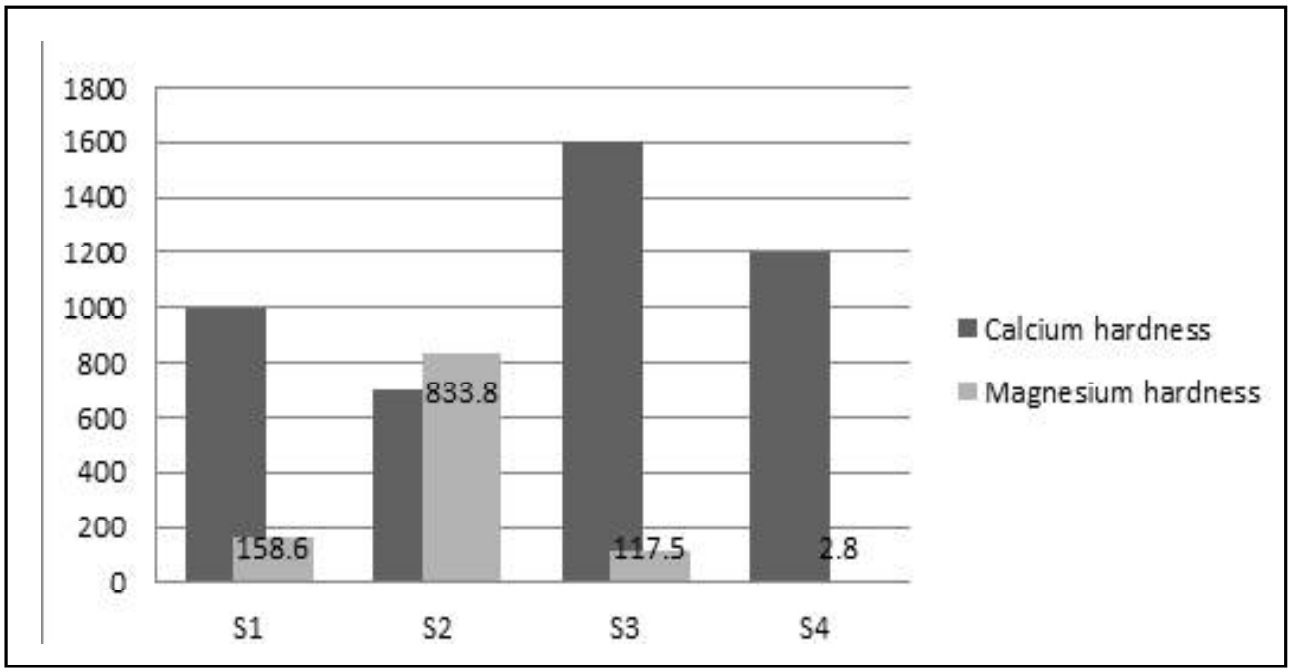
samples	pH	alkalinity	chloride	T.hardness
S1	9.5	102	21949.4	14000
S2	10.4	110	27420	69046
S3	11.2	120	18167.4	11238
S4	10.8	118	22962.6	6190.4



Graph 2. pH and Alkalinity of various samples.



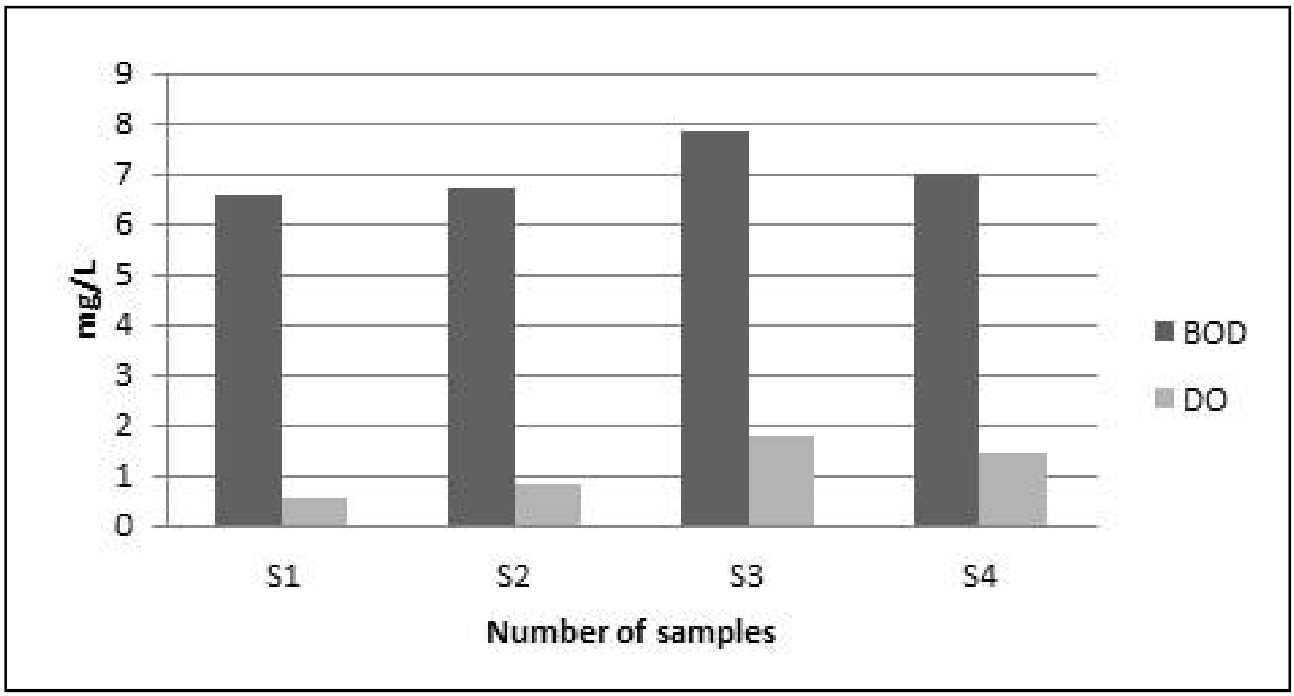
Graph 3. Total hardness



Graph 4. Calcium hardness and Magnesium hardness

either polluted or unpolluted based on Bureau of Indian Standards [67] and World Health Organization [65] guidelines.

Total Coliform and Faecal Coliform- it was found that the concentration of total coliform has been found maximum in all the four samples. Sample 3 has the maximum counts of TC i.e. 178.4 cfu/mL and faecal coliform are found maximum in sample 3 (11.2cfu/mL) (graph 1). These bacteria are gram negative bacteria and are the result of human interference. Faecal coliform are a group of bacteria found in the faeces of warm-blooded animals such as people, livestock, pets, and wildlife. The amount of faecal coliform in a stream or lake increases with the amount of sewage waste and/or manure [68]. The concentration of these bacteria in ocean waters has been used for decades to measure marine water safety. These bacteria are not necessarily pathogenic, but are found abundantly in wastes with human contributions where pathogenic organisms, such as viruses, are likely to exist [69]. Some of the symptoms of illness associated with faecal coliform and total coliform pathogens are minor, such as upset stomach, diarrhoea, ear infections, and rashes.



Graph 5. DO and BOD concentration

However, some pathogens, such as E coli, hepatitis, and Salmonella, can have very severe health effects. High levels of faecal coliform can cause other problems as well. Sewage and manure contain nitrogen and phosphorus, which act as fertilizer for algae and other aquatic plants. An overgrowth of plants can: • Deplete oxygen in the water that is needed by fish and other aquatic animals. • Affect the natural acidic/alkaline (pH) balance of water. • Interfere with recreational activities such as boating, fishing, skiing, and swimming. • Create odour problems and unpleasant views [70].

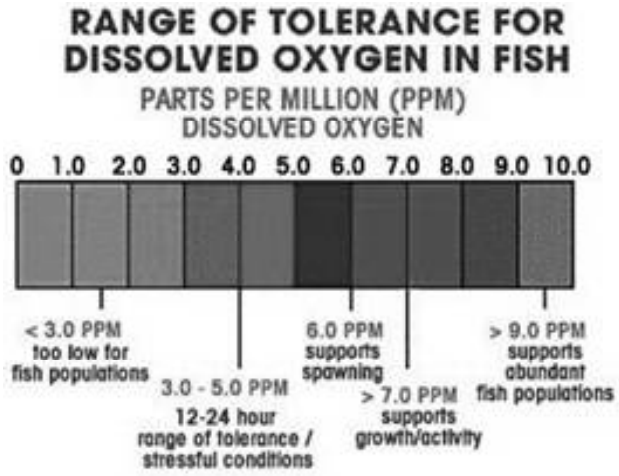
pH and Alkalinity- pH indicates acidity, alkalinity or neutrality of a water solution. Alkalinity defines the form of alkalinity as being bicarbonate, carbonate or hydrate alkalinity. Alkalinity is essentially a measurement of water's ability to neutralize acids. It is a measure of the buffering capacity of a system while pH is basically the measurement of the concentration of hydrogen ions in water, in terms of acidity or alkalinity. Maximum pH was recorded in sample 3 (11.2) (graph 2) which makes it a little alkaline and maximum alkalinity was recorded at 120mh/mL in sample 3 which is the ability of water of sample 3 to neutralize acids.

Total hardness (Calcium and Magnesium) - Total hardness is defined as the sum of calcium and magnesium hardness in mg/L as CaCO3.

After Na+, the two most abundant cations in seawater are Ca2+ and Mg2+. Ultimately, the Ca and Mg derive from the weathering of rocks on the continents, which rivers then sweep to the sea. Generally, marine water is considered as the highly measured hard water because it is the ultimate relieving point of all types of waste water and drainages which makes it harder. Maximum hardness was recoded in sample 2 (69046mg/mL) and least was in sample 4 (6190.4mg/mL). sample 2 which is Calangute beach has the highest hardness recorded that means that it is mostly used for bathing and other water sport activities [71]. In case of calcium and magnesium it was found that the maximum calcium ions are found in sample 3i.e. 1600mg/mL and magnesium is in sample 2 i.e. 833.82mg/mL.

Dissolved Oxygen- The actual amount of dissolved oxygen (in mg/L) will vary depending on temperature, pressure and salinity. A dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality [72]. Dissolved oxygen is necessary to many forms of life including fish, invertebrates, bacteria and plants [73]. These organisms use oxygen in respiration, similar to organisms on land. Microbes such as bacteria and fungi also require dissolved oxygen. These organisms use DO to decompose organic material at the bottom of a body of water [74] which is found maximum in sample 3 i.e. 1.82mg/mL and least in sample 1 i.e. 0.58mg/mL. In the ocean, coastal fish begin to avoid areas where DO is below 3.7 mg/L, with specific species abandoning an area completely when levels fall below 3.5 mg/mL. Below 2.0 mg/mL, invertebrates also leave and below 1 mg/mL even benthic organisms show reduced growth and survival rates [75].

Biochemical oxygen demand- Biochemical oxygen measures the amount of oxygen that microorganisms consume while decomposing organic matter, it also measures the chemical oxidation of inorganic matter BOD is a measure of organic material contamination in water, specified in mg/L. BOD is the amount of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic materials (e.g., iron, sulphites). Typically the test for BOD is conducted over a five-day period. High BOD level represents high pollution rate. Highest BOD was recorded in sample 3 i.e. 7.84mg/mL which is very high for aquatic life.



CONCLUSION

The study aims to know the microbiological and physico-chemical characteristics in the water quality based on anthropogenic inputs. Viral and bacterial contamination of recreational coastal water is a rising public health concern. The aim of our study was to conduct a preliminary evaluation of the presence of indicator pathogens in seawater. Indicator microorganisms (such as TC, FC) have been used as models for the potential presence of pathogenic microorganisms in water samples. The effects of water pollution are not only devastating to people, but also to animals, fish, and birds also destroy aquatic life and reduce its reproductive ability. Polluted water is unsuitable for recreation, agriculture, and industry. Eventually, it is a hazard to human health. Present paper suggests that the water available for bathing at the popular beaches of Goa is not safe for recreational purposes. For marine water quality, total coliform, faecal coliform, can be used as pollution indicators especially for public places like beaches, but total coliform and faecal coliform are better indicators for marine waters. This study demonstrated that coastal beaches of Goa were not safe for human activities with body contact such as swimming. The rank order in terms of level of

pollution at Port Goa are the Baina Beach (3) > the Grandmother's hole Beach (4) > the Baga beach (1) > the Calangute Beach (2). The origin of these bacteria, whether indigenous or derived from outside sources, is speculative but we have presented evidence of a population that exists in equilibrium and is responsive to increased nutrients and permissible growth conditions and, presumably, seasons. Based on these findings, the Goa coast is contaminated by urban domestic sewage, and industrial effluents. Thus the study illustrated the application of the statistical technology to identify the microbial quality of Goa coastal region and to determine further monitoring or prevention of the coastal zone. The present study shows that the addition of sewage discharge affects the quality of sea water. The disposal, management and proper utilization of waste products has become a concern for the scientists and environmentalists. Proper management of solid waste is necessary to safeguard our environment. Hence, the effluent from solid waste or from industries should be treated properly before released into the marine environment. Poor water quality could lead to loss of biodiversity. Enforcement of environmental laws and obeisance of maritime law of the Sea should be taken more seriously in the coastal maritime States to avoid loss of aquatic life. More funds should be channelled to researches on water quality, biomass estimate and Surveillance survey. Training and sensitization of fisher folks on responsible fisheries and basic record-keeping habits should be conducted at regular intervals.

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