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Environmental status of some beaches in Daman and South Gujarat, India

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Beaches are the prime choice of amusement, hence determining its quality is significant to public health. The existing status of water and sediment quality of four beaches along the north-west coast of India is evaluated at high and low tide (for three weeks) during the pre-monsoon season. Water samples were measured for hydrography, nutrients, Petroleum Hydrocarbons (PHc) and Fecal Coliform (FC). Sediments were analyzed for heavy metals, PHc and FC. Results indicated higher concentrations of ammonia (28.7 µmol/l) and phosphate (57.3 µmol/l) in the waters of Tadgam beach owing to the proximity to industrial discharge. Metals such as Fe, Al, Mn, Cr, Zn, Cu, Ni, Co, and Hg were found to be above Lowest Effective Range (LER) as compared to Cr and Fe, those exceed Severe Effective Range (SER). Elevated levels of FC in both water and sediment in all the studied beaches indicated microbial contamination relative to anthropogenic activities.

[**Keywords**: Fecal coliform, Metals, Nutrients, Sediment, Water, West coast of India]

Introduction

At present, the coastal regions are deteriorating at a great pace due to pollution caused by industrial outlets and domestic sewage[1]. Most of the human habitat and industrialization take place beside water bodies due to the comfort of waste discharge and easy utilization of water. Developmental activities due to population rise also play a critical role in accelerating disturbance in coastal environments. India is a tropical country having the majority of its borders fronted by water, with the total coastline accounting about 7516 km, having population along with coastal districts of 171 million (iomenvis.nic.in). The west coast of India is relatively crowded with two major industrial states (Gujarat and Maharashtra). There are approximately 99 recreational beaches along the west coast of India. Having majority of coastal towns, most of the population is diverted to beaches for recreational purposes. Taking this into consideration, it is of prime importance to understand sources and physical processes that accelerate beach contaminants thereby decreasing the aesthetic beauty of beaches. Additionally, monitoring microbiological contamination is also a necessity as it is associated with numerous health risks and enteric illness while the presence of the same also indicates confluence of untreated sewage water with beach water[2]. As India is developing economically at a faster pace, it is indicative that there will be significant growth in tourism infrastructure. Clean beaches are therefore valuable nodes for recreational users which in turn promotes the economic status of the country. Thus, to enhance tourist attraction, it is vital to prevent environmental degradation of beaches. Present study is an attempt to monitor the physico-chemical and microbiological aspects that affect beaches in certain ways and may have a negative impact on tourism activity.

Macro pollutants such as manmade debris enhance chemical and biological factors and affect negatively[2], which harms the intrinsic value of beaches. As per the study undertaken by South Asia Co-operative Environment Programme (SACEP, 2018), three major sources of marine litter were noted at Indian beaches accounting to plastic, waste generated by tourists and sewage-related debris. Thus, to enhance the aesthetic beauty of the beach and attract tourism, marine debris must be taken care of, as the majority of them are non-biodegradable and persists in the environment for a long time. Taking the globe into consideration, many of the beaches are routinely groomed to remove sea-grass, algae, and litter for enhancing serenity and tourist health. The same should be implemented in the beaches understudy recognizing the growth in beach activity[3].

Keeping in mind, tourism and economic status of Daman, along the north-west coast of India, it is vital to maintain the beach quality of this coastal land and the available data can also be made useful for further management decisions in improving the coastal ecosystem. The present study was designed to study the quality of beaches in Daman and neighboring two beaches *viz*. Tithal Beach and Tadgam beaches along the Gujarat coast. The ever-increasing population and industrial growth negatively affect marine biodiversity and finally threatens the aquatic life thereby indirectly affecting humans[4]. The proposed study can be regarded as pilot study for snapshot observation of tourism important beaches at west coast of India to determine the pollution status as many articles reported degradation of coastal environment along the west coast of India[5,6]. Also, two rivers namely Damanganga and Kolak can be considered as a source of pollution as they migrate through the industrial towns housing textile, paper and pulp, chemical-based, rubber, plastic and mineral based industries. Around 23 large scale and few small-medium scale industries are located in Daman and nearby areas (dcmsme.gov.in). The study conducted on Damanganga in the year 1979 reported the discharge of wastewater around 3.9×10^3 m^3 day^{-1} from the industrial sites located at Vapi (20°20'32.57" N, 72°54'35.24" E) and Silvassa (20°17'38.74" N, 72°58'55.71" E). However, no seasonal surveys have been conducted, and necessary attempts must be made to monitor river currents that flow into the recreational beaches to mitigate the chemical and microbial exposure to coasts.

Materials and Methods

Study area

Coastal water and beach sediments were collected from four beaches *viz*. Jampore and Devka located in the Union territory of Daman and Tithal and Tadgam located in southern Gujarat. The monitoring was carried out in three consecutive weeks of March, 2018. Water and sediment samples were collected at two stations on every single beach at Low Tide (LT) and High Tides (HT). Water and sediment samples from areas close to visible effluent discharge site such as pipeline located in the vicinity of Tadgam Beach (TGD) were also collected. A total of 54 water samples and 27 sediment samples were collected throughout the study period. The entire stretch of the study covering all the four beaches along the west coast of India accounts for ~50 km frontier of the Arabian Sea (Fig. 1). Two major rivers named Daman

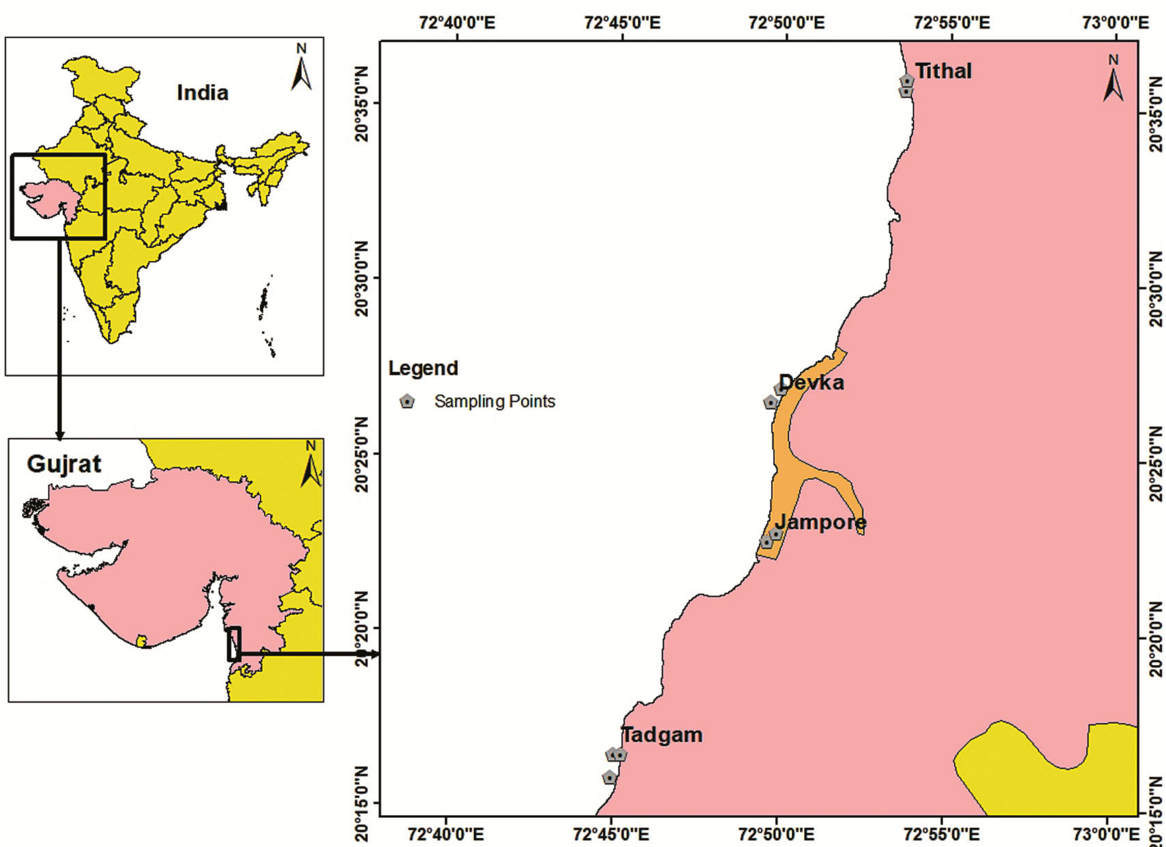

Fig. 1 — Location of the studied beaches of Daman and south Gujarat, north-west coast of India

Ganga (20°24'44.33" N, 72°49'58.87" E), originates from Sahyadri hills (length 131 km) and Kolak River (20°27'58.59" N, 72°51'26.45" E), originates from Saputara mountain range (length 50 km) drains in the Arabian Sea along this stretch.

The studied beaches can be described as Tadgam, Gujarat which is next to the village Tadgam inhabiting 2541 individuals and 513 houses (Census, 2011). Jampore beach is flat, while the rivulet flow joins the beach at its southern tip. Devka beach has long coastline with the rocky formation which can be seen during the low tide condition. Tithal beach is located near the industrial town Valsad, Gujarat.

Analytical methodology

Surface water samples at each station were collected in a pre-cleaned polypropylene bottle. Samples for Dissolved Oxygen (DO) were collected in a glass bottle, fixed immediately with Winkler's solutions and thereby oxidized using hydrochloric acid (50 % v/v). The liberated iodine was titrated using standard sodium thiosulphate (0.01 N Na_2SO_3) solution[7]. Samples for nutrients were analyzed by colorimetry method using an Autoanalyzer (Model: Skalar San plus system). The relative error of nutrient analyses (nitrate, nitrite, ammonia, and phosphate) was measured repetitively (at least 20 times) as well as relative to international seawater standard (OSIL, UK) was < 5 %. PHc in water samples were extracted using n-Hexane evaporated and measured using a Spectro fluorophotometer (Model: Shimadzu RF 5301: emission wavelength 360 nm; excitation wavelength: 310 nm)[8]. Water samples for the microbiological study were taken in a pre-sterilized bottle and after serial dilutions, it was analyzed using the spread plate technique for FC using media mFC agar[9].

Sediments at each station were collected in polyethylene bags for the determination of metals, PHc, and microbiological parameters. For the PHc analysis, briefly 100 g wet sediment was treated with potassium hydroxide (KOH) and methanol (CH_3OH) in a hot water bath (80 – 85 °C), filtered and extracted using n-hexane. The aliquotes was then passed through an Al_2O_3 filled glass column along with n-hexane and methylene chloride (CH_2Cl). The residual solution was collected and then evaporated and diluted with n-hexane before measuring in a Spectro fluorophotometer[10]. Briefly, 1 g sediment was used for FC counts in 100 ml phosphate buffer saline as a medium, from which 0.1 ml was taken for analysis on mFC agar plate. Powdered and homogenized sediment samples were used for metal analysis. The sediment samples were digested using concentrated hydrofluoric (HF), perchloric ($HClO_4$), hydrochloric (HCl) and nitric (HNO_3) acid mixture[11]. All the chemicals and acids used were of supra-pure grade (Merck, Germany). After digestion, samples were diluted to constant volume with Milli-Q water and metal analysis was performed immediately on the resultant solution using ICP-OES (Optima 7300DV, Perkin Elmer) for Fe, Mn, Cr, Co, Ni, Cu, and Zn. For Hg analysis, sediments were digested with aqua Regia followed by oxidization with $KMnO_4$. The oxidized samples were decolorized with hydroxyl ammonium chloride and further reduced using alkaline sodium borohydride. Analysis of Hg was carried out using cold vapor generation technique on Flow Injection Mercury System (FIMS-400, Perkin Elmer) coupled with an amalgamation system for on-line pre-concentration. To authenticate the results, CRM MESS-3 and PACS-2 were also analyzed along with each set of analyses (NRCC, Canada). The precision/accuracy was better than ± 5 % for all metals. Grain-size (Texture) of sediment was segregated in terms of contents of clay (< 4 μm), silt (4 – 63 μm) and sand (> 63 μm) using wet-sieving method. Dried sediments were added with Sodium hexametaphosphate [$(NaPO_3)_6$] and then passed through 63 microns sieve for sand. The supernatant solutions were separated based on density, dried and weighed for clay and silt content. The entire procedure has a measurement error of 3 – 5 % in this study.

Results and Discussion

Water parameters

In the conducted study during summer season (March, 2018), the measured atmospheric temperature was in the range of 24.5 to 36 °C. Coastal water temperature was in the range of 25.5 to 35 °C throughout the study. pH values obtained were within the range of 7.7 to 8.6, which were within the permissible limits prescribed by the Central Pollution Control Board (CPCB) under class SW II for recreational waters. Salinity values were in the range of 26.0 to 36.3 Practical Salinity Units (PSU). The lowest value was obtained at Tadgam in the vicinity of discharge point (Tadgam DP) during low tide conditions, which indicated mixing of seawater by effluent, which is mainly from domestic sewage or effluent. Changes in the chemical status of the beach can occur naturally or anthropogenically. Mainly in the recreational beaches, water is affected by anthropogenic factors which include discharges, public waste, improper solid waste management, infrastructure development, etc. The beach water was seen much aerated in most of the location while the low DO values (< 4 mg/l) were observed at Tadgam effluent discharge point (DP) during the low tide indicating consumption of DO during oxidation of organic matter associated with industrial effluent[12]. Along the rest of the beaches, average DO values were observed > 5.5 mg/l, which indicated better coastal water conditions (Fig. 2). Three locations, JP-2 in phase II and TG and DP in phase I and II showed DO < 5.0 mg/l, which is below normal condition[13]. However, the conditions were seen recovered in the final phase of monitoring. The recovery was observed due to lower prevalence of Organic Matter (OM)

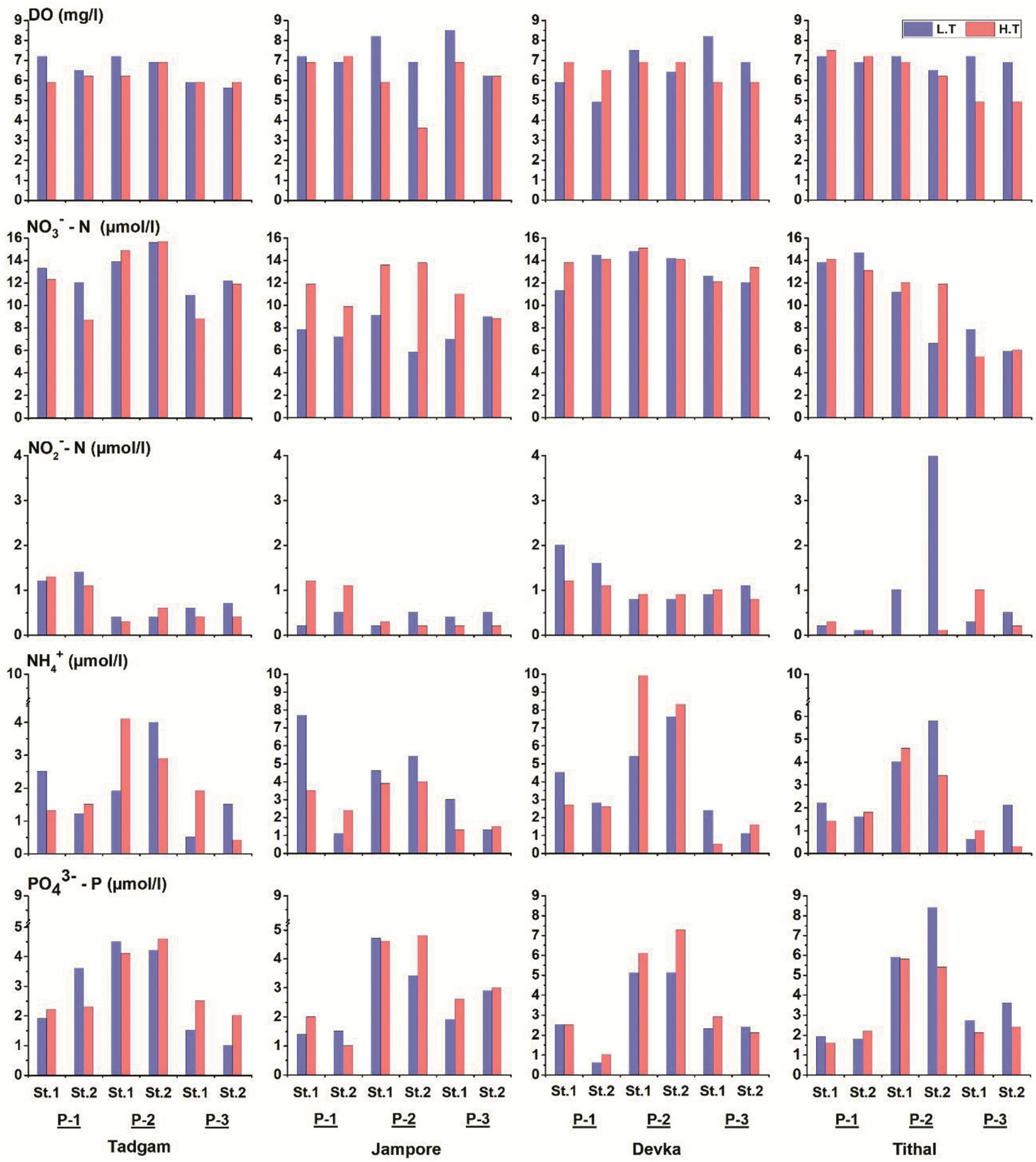

Fig. 2 — Distribution of DO (mg/l) and nutrients (µmol/l) during three phases, phase-1 (P-1), phase-2 (P-2) and phase-3 (P-3) of studies at stations 1 and 2 during high tide and low tide conditions along the Tadgam (TG), Jampore (JP), Devka (DK) and Tithal (TL) beaches

which consumes DO during its breakdown. Total suspended solids measured were higher, which decrease the visibility and light penetration in seawater. The concentration of Total Suspended Solids (TSS) in nearly 50 % of the samples was > 500 mg/l. The higher TSS values attributed to the presence of higher silt and clay in the sediment from the beaches. Unclear water may be due to wave action that generates turbulence especially during pre-monsoon, which resuspends silt varying from 12.1 – 94.8 % and 0.1 – 25.8 % clay in bottom sediment thereby increasing the turbidity in water[14]. This indicates much of the beaches were enriched with finer grain-size thus escalating resuspension of TSS.

Nutrients such as forms of nitrogen and phosphorus are essential for the survival of phytoplankton, while the excess of them can cause algal blooms[15], which depletes dissolved oxygen levels in the water. The anthropogenic sources of these nutrients are from industrial discharges, sewage and fertilizer drain from the agricultural land in nearshore environments[16]. The levels of PO_4^{3-}-P were in the range of 0.6 µmol/l to 57.3 µmol/l during this study. NO_2^--N, an intermediate state between oxidation of NH_4^+-N and reduction of NO_3^-N and is thermodynamically unstable and its concentration remains < 1 µmol/l in the coastal sea[17]. Its concentration was a maximum of 4 µmol/l at Tithal beach during low tide. The higher values obtained in this study may be related to the discharge of domestic and industrial effluent contributing to the accumulation of NO_2^--N in this water before its oxidation to NO_3^-N[18]. NO_3^-N is an important form of inorganic nitrogen as its presence contributes generally over 60 % of total inorganic nitrogen, was in the range of 3.7 – 15.1 µmol/l in this study. As per the Environmental Protection Agency (EPA), excess of NO_3^--N in seawater can cause hypoxic conditions making the environment toxic for aquatic life[19]. The interrelationship between NO_2^--N and NO_3^--N was always positive irrespective of the tide in all the beaches. However, a moderately weak correlation was seen in the interrelationship between NO_2^--N and NO_3^--N at Tithal beach (0.57 – 0.43) along with Jampore during LT (0.38). Broadly, the values of PO_4^{3-}-P were in the range of 1.54 – 6.95 µmol/l, with a mean value of 4.4 µmol/l and the values of NO_3^--N was in the range of 0.2 – 2.3 µmol/l with mean value of 1.07 µmol/l (Fig. 2). The range of PO_4^{3-}-P and NO_3^--N obtained during this study was higher as compared to previously reported results[20]. NH_4^+-N is a widespread pollutant found in beach waters, its concentration beyond the certain permissible limit is said to be harmful to aquatic life[21]. The observed limit of 0.2 mg/l ≈ 11.7 µmol/l indicates toxic water for aquatic species[21]. Comparing with these limits, the NH_4^+-N values at Tadgam DP were higher (12.8 µmol/l and 28.7 µmol/l in I and II phases, respectively). The high concentration obtained may be the result of the decomposition of organic matter discharged in the form of sewage or partially treated effluent. Other possible reasons could be the generation of ammonia due to the dissimilation of NO_3^--N and/or from proteins, amino acids and urea, which are the prime ingredient of fertilizers[22]. Another possibility of comparatively higher values may also due to the impact of the discharge of partially treated effluent and sewage[23] that is discharged into Daman Ganga and Kolak river, which finally opens to the Arabian Sea giving rise to enhancement of nutrients in the beach[24]. Variation in nutrients observed during high and low tide conditions, due to the effect of wave-driven currents[25] are presented in (Table 1). Hence, to decrease the concentration of nutrients which may possibly cause eutrophic conditions, the wastewater and industrial discharges should be made into 20 m water depth[26]. This will influence the diffusion and dispersion of pollutants and reduce its impact on coastal water.

Table 1 — Ranges of DO and nutrients recorded in the water in the vicinity of different studied beaches

Stations	Range and SD	DO (mg/l)		NO_3^--N (µmol/l)		NO_2^--N (µmol/l)		NH_4^+-N (µmol/l)		PO_4^{3-}-P (µmol/l)	
		Low tide	High tide	Low tide	High tide	Low tide	High tide	Low tide	High tide	Low tide	High tide
Tadgam	Range	3.3-7.8	5.9-6.9	3.7-15.6	5.5-15.1	0.3-1.4	0.3-1.3	0.5-28.7	5.5-15.7	1.0-57.3	2.0-4.6
	SD	1.56	0.32	3.29	3.04	0.34	0.39	8.75	3.04	17.08	0.96
Jampore	Range	6.2-8.5	3.6-7.2	5.8-9.1	8.8-13.8	0.2-0.5	0.2-1.2	1.1-7.7	8.8-13.8	1.4-4.7	1.0-4.8
	SD	0.79	2.5	1.26	1.82	0.13	0.44	2.33	1.82	1.17	1.35
Devka	Range	4.9-8.2	5.9-6.9	11.3-14.8	12.1-15.1	0.8-2.0	0.8-1.2	1.1-7.6	12.1-15.1	0.6-5.1	1.0-7.3
	SD	1.07	0.45	1.33	0.9	0.45	0.13	2.14	0.9	1.6	2.26
Tithal	Range	6.5-7.2	4.9-7.5	5.9-14.7	5.4-14.1	0.1-4.0	N.D-1.0	0.6-5.8	5.4-14.1	1.8-8.4	1.6-5.8
	SD	0.31	1.47	3.44	3.41	1.37	0.33	1.71	3.41	2.38	1.68

Petroleum hydrocarbons (PHc) in water arises due to anthropogenic sources such as oil spillage, leakages in fishing trawlers or boats or discharge of petroleum product in water. Many studies confirmed the deposition of tar ball along the west coast of India during pre-monsoon, which resulted due to leakage of oils in offshore oil fields and oil spillages by container ships[27]. PHc values were found to be in the range of 6.0 – 7.0 µg/l for all the beaches excluding Tadgam DP point which revealed the average value of 15.2 µg/l and higher than that obtained at other stations indicating petroleum-based discharge of effluents.

Microbiological aspects

During the three-phase study of beaches, the concentration of FC was in the order of Jampore> Devka> Tithal> Tadgam with highest FC pollution at Jampore and lowest at Tithal. Respective values obtained were in the range of 3 – 25, 4 – 5, 2 – 4, 0 – 5 CFU/ml which exceeded CPCB limit of 1 CFU/ ml showing a severe threat to the tourists. It is estimated that around 120 million cases of gastrointestinal illness and 50 million cases of respiratory diseases are reported due to recreational activities in sewage polluted beaches[28]. Fecal indicator bacteria like *Escherichia coli* and *Enterococci* are widely used as indicator bacteria and their presence is an indication of other pathogenic bacteria that are often excreted in feces. Accidental swallowing of such contaminated water during recreational activities leads to illness like gastroenteritis, acute respiratory disease and eye, ear and skin infections[25]. Considering such serious impacts of biologically polluted water, treated water must be discharged into the sea. Study performed at Mumbai; west coast of India also revealed recreational beaches polluted due increase in domestic sewage discharge considering FC as indicator[29].

Hierarchical cluster analysis

The hierarchical clustering or dendrograms indicate the variation in dissimilarity between the stations[30]. The vertical line referred to as Y-axis indicates the name of stations while horizontal *i.e.* X-axis indicates distances or dissimilarity points. Stations having little or no dissimilarity are placed closed to each other like in case of DK 1-DK 2, JP 1-JP 2, TG 1-TG 2 have nearly similar properties in context to nutrients at low tide, while DP at Tadgam shows highest dissimilarity factor showing higher values as compared to all other stations plotted (Fig. 3). High distance traveled by DP indicates the highest effluent and sewage discharge activities that are evident from Tadgam discharge point. Due to higher values of NH_4^+-N and PO_4^{3-}-P obtained at Devka the distance traveled by them shows increased nutrient pollution during hightide conditions owing to the confluence of Damanganga River and Kolak River. However, DP shows recovered conditions during high tide, which might be due to the effect of dilution.

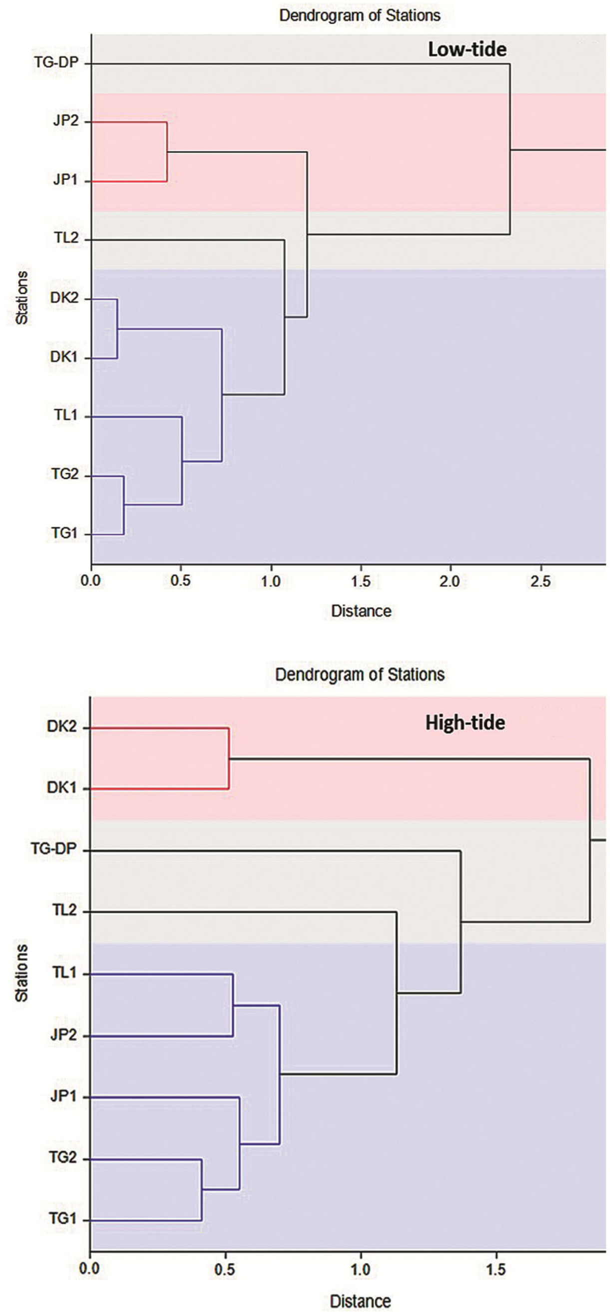

Fig. 3 — Dendrogram showing similarity among status based on DO (mg/l) and nutrients (µmol/l) during different tidal conditions along the studied beaches

Sediment analyses

Chemical aspects

Apart from bathing and water sport at beaches, the majority of tourists spend their time basking, playing or walking naked feet which contacts beach sediment. Contaminated sediment has a probability of containing toxic materials that may affect human health or environment[31]. Hence it becomes important to monitor the beach sediment and its quality to make sure it is harmless for recreational use. For determining sediment quality, PHc and metals were analyzed. While the probable source of PHc is known, adsorption of metals in sediment is from industrial and domestic discharges in seawater[32], which can be transported to the inland beach due to the action of a wave. A higher concentration of PHc restricts the growth of an aquatic organism, gives objectionable smell or flavor to fishes thus decreasing their economic value[33]. PHc were obtained in a range of 0.1 – 0.6 µg/g (wet sediment) with mean 0.25 µg/g at all beaches, with higher value at Tadgam DP (1.93 µg/g). The obtained values of PHc were seen lower as compared to PHc found in Tamil Nadu, Indian coast[34] and those reported along the coast of Arabian Sea, India[35].

Anthropogenic factors responsible for metal pollution in sediments mainly involve untreated domestic and industrial wastewater release, which after precipitation gets attached to suspended matter[36]. The grain size revealed that the beaches of Jampore and Devka are highly dominated with silt (83 – 91 %) with lower concentration of sand (2 – 17 %) and clay (0 – 26 %). In the case of Tadgam and Tithal, comparatively low concentration of clay (1 – 21 %), while distribution of sand and silt was (20 – 94 %) and (44 – 94 %), respectively. Thus, the concentration of metals in sediment was seen to be on the higher side due to domination of finer grain size (silt and clay), which adsorbs metal due to their smaller grain size and larger surface area[48] (Table 2). Comparing with study conducted along the west coast of India before and after the commissioning of Bombay Disposal Sewage Project (BDSP), along the coastline of the present study, revealed lower concentrations of Cr, Ni, Cu, Zn than that in the present study[37]. Concentrations of Cr and Zn were higher at Tadgam and Tithal. The concentration of Cr (138 – 224 µg/g) exceeded Severe Effective Limit (SEL) indicating chromium contamination in all the beach sediment[38]. While study performed by CSIR-NIO, 2012 along the coast of Daman indicated values in the range (µg/g) of 95 – 223, 801 – 1053, 23 – 32, 50 – 58, 79 – 111, 85 – 108 for Cr, Mn, Co, Ni, Cu, and Zn, respectively indicating a slight change of metal concentration as compared to present study. The contaminated sediment in some beaches might be the cause of certain anthropogenic factors like coastal construction, industrial discharges and tourist activities which causes metal input[39].

Microbiological aspects

The sediment usually has higher counts of bacteria as they remain protected from deactivation by sunlight and nutrient scarcity[25]. The reports of tourists' illness due to contact with contaminated sands are well published;

Table 2 — Comparison of sediment quality between present studies and other studied tourist beaches across the world

Beaches	Al (%)	Cr (µg/g)	Mn (µg/g)	Fe (%)	Co (µg/g)	Ni (µg/g)	Cu (µg/g)	Zn (µg/g)	Hg (µg/g)	Study
Tadgam	4.3-6.8	169-285	924-1330	7.5-10.5	42-66	55-64	46-87	76-112	N.D-0.01	Present study
Mean	5.2	224	1085	9	53	60	61	91	0.07	
Jampore	3.7-7.3	137-211	985-1755	7.9-9.3	40-70	46-54	40-88	63-96	N.D-0.14	Present study
Mean	4.8	148	1058	7	44	43	59	74	0.06	
Devka	6.2-7.7	136-181	1070-1235	8.7-9.7	38-49	53-56	79-96	99-118	0.07-0.09	Present study
Mean	6.1	138	960	8	38	46	77	93	0.07	
Tithal	5.6-7.5	146-295	1142-1535	9.3-14.4	44-91	53-63	98-123	107-184	N.D-0.14	Present study
Mean	5.5	164	1097	9	52	49	90	111	0.07	
Mumbai[40]	…	40- 527	328-793	1.2-8.8	63-125	45-94	15-48	28-83	…	(40)
Pre-commission[37]	…	151–189	…	…	…	57– 98	72– 99	73– 91	…	(37)
Post- commission[37]	…	64–171	…	…	…	28– 90	72– 96	74– 103	…	(37)
Chennai (avg.), India[42]	…	14.1	46.84	44.2	5.05	9.17	4.05	9.89	…	(42)
Al-Khobar coast, Saudi Arabia[39]	…	51.03	113.97	…	4.75	75.1	182.97	52.68	0.8	(39)
South Darban, S.A[43]	…	223-352	605-1039	…	45-52	93-118	28-42	31-57	1-2	(43)
LEL[38]	…	26	460	2	…	16	16	120	…	(38)
SEL[38]	…	110	1100	…	…	75	110	820	…	(38)

however, there are no standards to implement for sediment quality. While sediment at Tadgam showed an absence of FC, they were detected only once at Tithal indicating the non-point source of pollution. Considering the sediment of Devka, FC was intensely contaminated as compared to Jampore. Values obtained for Jampore and Devka were 100 – 200 and 100 – 300 CFU/g, respectively. However, awareness must be made against the possible consequences among the visitors. As treatment for the illness caused by contaminated water with high FC is getting difficult, beach management program should be implemented promoting beach closing which is followed by developed countries. The same should be practiced in India too as it is also advised by WHO[41] under guidelines for safe recreational water environments, 2003. As compared to FC contaminated water, it is clearly evident that FC has less capability to bind sediment.

Conclusion

Four prime beaches along the west coast of India were studied on account of contamination. Results of study highlights excess anthropogenic load, especially in Tadgam beach. FC is found higher than the permissible limit indicating contamination by microbial communities. Sedimentary metal compositions were above Lowest Effective Limit (LEL) and lower than SEL except for Cr and Fe, indicating anthropogenic pollution due to release of industrial effluents and sewage. Hence discharges through the inlet waters must be treated well before its release. The impact of contaminants can be significantly lowered when remedial measures are taken at the source of pollution considering safety of recreational users.

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Conflict of Interest

Respective authors of the Manuscript declare that there is no conflict of interest.

Ethical Statement

This is to certify that the reported work in the paper entitled "Environmental status of some beaches in Daman and south Gujarat, India" submitted for publication is an original one and has not been submitted for publication elsewhere. I/we further certify that proper citations to the previously reported work have been given and no data/table/figure has been quoted verbatim from other publications without giving due acknowledgement and without the permission of the author(s). The consent of all the authors of this paper has been obtained for submitting the paper to the "Indian Journal of Geo-Marine Sciences".

Author Contributions

AR made the fund acquisition. UKP & SL prepared and conceptualized the final draft of manuscript. Sampling and analysis along the beaches were done by SL, UPB, AG & LK for chemical aspects of sediment and water. Microbial study was done by ABF. The manuscript was reviewed by all the authors.

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