JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue

JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A POST-LOCKDOWN COMPARATIVE STUDY OF MICROBIAL AND ENVIRONMENTAL QUALITY OF RURAL AND URBAN BEACHES OF TAMIL NADU

[1*]S. Nandhini, [2]Abishikha. S

[1]Associate Professor, [2] Research Scholar

[1]Department of Microbiology,

[1]Ethiraj College for Women, Chennai, Tamil Nadu, India.

Abstract: Beaches are popular vacation destinations across the globe, and many nations have acknowledged the issue of seawater contamination. The present study was carried out to analyse the difference in quality between rural and urban beaches during post-lockdown. Water and soil samples were collected post-lockdown in the year 2021 and 2023 from Tiruchendur and Marina beaches in Tamil Nadu and were analyzed for physico-chemical and biological parameters. A statistical survey was also done to understand the awareness of the public in this area. Microbial presence was detected using spread plate technique and colonies were enumerated. According to the experimental results performed in the year 2021 and 2023, the number of bacteria in the soil sample was 6.55 $x10^6$ CFU/g (S1) and 6.4 $x10^6$ CFU/g (S2) and 2.43 $x10^7$ CFU/g (S1) and 2.9 $x10^7$ CFU/g (S2), respectively. Similarly, the bacterial count in the water sample was TLTC (S1 & S2) in 2021 and 6.5 x 10^8 CFU/mL (S1) and 7.0 $x10^8$ CFU/mL (S2) in 2023. Gram positive organisms such as *Staphylococcus sp., Sarcina sp., Micrococcus sp., Enterococcus sp., Corynebacterium sp., Bacillus sp*., were found to be the dominating organisms in seawater. The total coliforms and other Gram-negative organisms such as *E. coli, Pseudomonas, Aeromonas, Acinetobacter* were found to be high in sand, rather than in seawater during both the years. Due to high population activity, the samples collected after two years expressed high microbial load indicating increased contamination and suspended particulate matter.

IndexTerms **- Seawater, Marine, Gram-positive Organisms, Coliforms**

I. INTRODUCTION

Marine water pollution has been recognized globally as an issue that requires an important public health and environmental concern. In order to conserve the marine ecosystem and their diversity in deep oceans, Mission Blue has been started along with IUCN declaring 76 hope spots of ocean which are the Earth's blue heart. In specific, India has 2 hope spots, Lakshadweep and Andaman Nicobar Islands. Beach quality monitoring and assessments based on microbiological, physical and chemical parameters are taken into account as a vital part of coastal management programs due to the increased recreational activities. The quality of seawater is assessed by comparing with National and/ International standards (Davies et al., 1995; Andraus et al., 2014; Velonakis et al., 2014; Halliday et al., 2014; and DEA, 2012). Monitoring the presence of pathogenic bacteria is essential for water quality assessment, as it can directly or indirectly result in significant health issues for humans (Dibra et al., 2023 and Ichsan Rusydi et al., 2024). Many studies have reported the presence of *Enterococcus species, Aeromonas sp., Vibrio sp., Staphylococcus sp., Pseudomonas sp., Escherichia coli* etc. in beach sand, seawater, or both samples that can infect people (Elmanama et al., 2005; Curiel-Ayala et al., 2012 and Ahmad et al., 2013). These waterborne pathogens act as a source for various ailments like gastrointestinal, respiratory, skin, eye as well as ear infections (Sabino et al., 2014). The study of biodiversity and enumeration has been a greater option to understand the presence of various microorganisms and their count to prevent various diseases from spreading and maintain a sustainable and sanitary environment. This research was executed to analyze the extent of human intervention, post-covid lockdown relaxation, and changes in both land and water at their interface i.e., beach and seashore were assessed. The decrease in contamination on beaches and in coastal water has been observed globally where quarantine measures existed. In post-covid times, the waters in beaches of Acapulco (Mexico), Barcelona (Spain), Salinas (Ecuador) have become substantially more transparent and clearer (Zambrano-Monserrate et al., 2020). In this study, samples were collected from the shoreline of South India, Tamil Nadu, and quality assessments were done to explore the differences between rural and urban beaches and to figure out the impact of lockdown and current population activity on them.

II. MATERIALS AND METHODS

2.1. Study area

The study sites comprise Tiruchendur (8°29'46.7088" N, 78°7'30.306" E), a holy place located in Tuticorin district (near Tirunelveli) along the shoreline overlooking the Bay of Bengal in the South-eastern part of Tamil Nadu (Approximately 2000 km from Andaman Nicobar Islands) and Marina beach (13°03'15.05" N, 80°17'1.25" E), located in Chennai along the Bay of Bengal in the north-southern part of Tamil Nadu, which is an important urban sandy beach (Approximately 1500 km from Andaman Nicobar Islands).

2.2. Sampling

Composite soil and water samples were collected in the month of September, 2021 and August, 2023 from the coasts of Tiruchendur beach (S1) and Marina beach (S2). The samples were collected from the top 4 cm soil profile, where maximum microbial activity occurs, and thus most of the bacterial population is concentrated. Soil samples were collected (approx. 100g) in clean, dry and sterile polythene bags using sterilized spatula and water samples were collected in 1 L sterilized water cans and were carried to the laboratory for further analysis.

2.3. Physico-chemical analysis

The following physico-chemical parameters were used to analyse soil and water samples: pH, chloride test, sulphate test, suspended matter, organic and inorganic particles, specific gravity, and sedimentary texture analysis.

2.4. Isolation of microorganisms and enumeration

The water and soil samples collected from the study sites were analyzed immediately in order to isolate all viable bacteria. The samples were serially diluted in saline and aliquots from the dilution tubes were plated on Zobell Marine Agar plates by means of spread plate technique. The plates were incubated overnight at room temperature. After incubation, bacterial growth was observed and the number of colonies were enumerated as follows:

$$\textbf{Colony Forming Unit (CFU)} = \frac{\textbf{No. of colonies X dilution factor}}{\textbf{volume of sample (ml)}}$$

The isolated colonies showing different morphological characteristics were identified using Gram staining, motility and minimum biochemical tests and were confirmed using Bergey's Manual. The purified isolates were then cultured on Zobell Marine slant and stored at 4°C. Membrane filtration technique was also performed to determine the quality of water sample.

2.5. Statistical survey

An online survey was conducted using Google forms to know public understanding about water bodies and their ideology about using beaches for recreational activities and risk factors associated with it. The results were then analysed and data were depicted using pie and bar charts.

III. RESULTS

Soil and water samples were collected from Tiruchendur (S1) and Marina (S2) coasts and analyzed for various physico-chemical and microbiological parameters. The pH of water and sand from both the sites were found to decrease as shown in **Table 1**.

Table 1. pH of water and soil sample

SAMPLE	pH			
	2021		2023	
	S1	S2	S1	S2
WATER	8.20	7.91	7.84	7.27
SOIL	9.40	9.25	7.92	7.70

The chloride ions, sulphates, inorganic solids, organic solids content was found to be much higher than the permissible limit as represented in **Table 2**.

Table 2. Chemical analysis of water samples

S. No	PARTICULARS	RESULTS				STANDARDS
		2021		2023		
1	Chlorides as Cl^-	S1	S2	S1	S2	500 mg/l max. for RCC 2000 mg/l max. for PCC
		19458.25mg/l	**16565.04mg/l**	**19499.15mg/l**	**19073.71mg/l**	
2	Sulphates as SO_3	**1722.16mg/l**	**1635.67mg/l**	**2292.89mg/l**	**2219.45mg/l**	400mg/l max.
3	Inorganic Solids	**34630.00mg/l**	**28841.00mg/l**	**34325.00mg/l**	**33549.00mg/l**	3000mg/l max.
4	Suspended matter	3.20mg/l	3.20mg/l	1.00mg/l	1.00mg/l	2000mg/l max.
5	Organic Solids	**24983.00mg/l**	**11624.00mg/l**	**3373.00mg/l**	**2739.00mg/l**	200mg/l max.

Soil texture of Tiruchendur sand was observed to be finer with less medium sized particle and soil texture of Marina sample was observed to be less fine with more medium sized particle (**Table 3**).

Table 3. Texture analysis of soil samples

SOIL TEXTURE		S1	S2
GRAVEL		0	0
SAND	COARSE	0	0
	MEDIUM	55	64
	FINE	42	36
SILT & CLAY		3	0
ATTERBERG LIMITS (%)	LIQUID LIMIT	21	18
	PLASTIC LIMIT	Nil	Nil
	PLASTICITY INDEX	Non-Plastic	Non-Plastic

Specific gravity and chloride test of soil samples are given in **Table 4**. Organisms were isolated from water and soil samples by spread plate technique and were enumerated (**Table 5**).

Morphologically distinct colonies from marine water and soil samples were purified and identified by microscopic and biochemical analysis (**Table 6**). In both water and soil samples mainly Gram-positive organisms like *Staphylococcus, Sarcina sp., Micrococcus, Enterococcus, Corynebacterium*, and *Bacillus* were found to be predominant. Gram negative organisms like *E. coli, Pseudomonas, Aeromonas, Acinetobacter* were observed less dominant. Water samples from both the areas were analyzed for the presence of fecal indicators by membrane filtration technique. After incubation, no growth of *E. coli* was observed on the Eosin Methylene Blue (EMB) agar.

Table 4. Specific gravity and chloride test of soil samples

TEST	RESULTS			
	2021		2023	
	S1	S2	S1	S2
SPECIFIC GRAVITY	2.71	2.67	-	-
CHLORIDE (%BY MASS)	0.16	0.01	0.16	0.18

Table 5. Microbial count of water and soil samples

YEAR	SAMPLE	Microbial count of water samples (CFU/mL)	Microbial count of soil samples (CFU/g)
2021	S1	TLTC[1]	TNTC[2]
		TLTC	6.50×10^6
	S2	TLTC	0.96×10^6
		TLTC	6.4×10^6
2023	S1	2.70×10^7	TNTC
		6.50×10^8	2.43×10^7
	S2	2.99×10^7	TNTC
		7.0×10^8	2.9×10^7

Table 6. Biochemical properties of the isolated organisms

S.No	Organism	Gram Staining	Motility	Pigment	Oxidase	Catalase	IMViC	Urease
1.	*Staphylococcus*	Gram positive cocci	-	-	-	+	-	+
2.	*Sarcina sp.*	Gram positive cocci	-	**orange**	+	-	-	-
3.	*Micrococcus*	Gram positive cocci	-	**yellow**	+	+	-	-
4.	*Enterococcus*	Gram positive cocci	-	-	-	-	-	-
5.	*Corynebacterium*	Gram positive bacillus	-	-	-	+	-	-
6.	*Bacillus*	Gram positive bacillus	+	-	+	+	-	-
7.	*E. coli*	Gram negative bacilli	+	-	-	+	+ + --	-
8.	*Pseudomonas*	Gram negative coccobacilli	+	-	+	+	- - - +	-

[1] TLTC – Too low to count
[2] TNTC – Too numerous to count

9.	*Aeromonas*	Gram negative coccobacilli	+	-	+	+	+ + + +	-
10.	*Acinetobacter*	Gram negative bacilli	-	-	-	+	- - - +	-

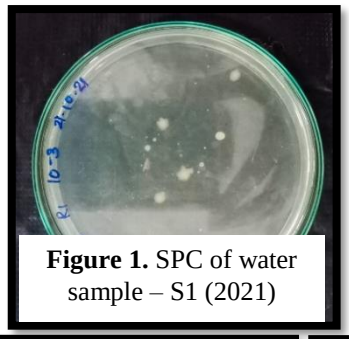

Figure 1. SPC of water sample – S1 (2021)

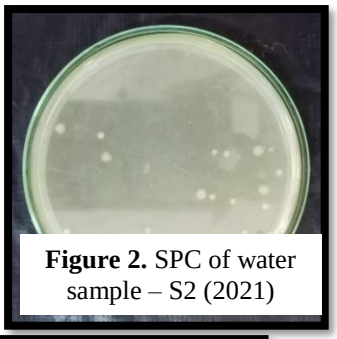

Figure 2. SPC of water sample – S2 (2021)

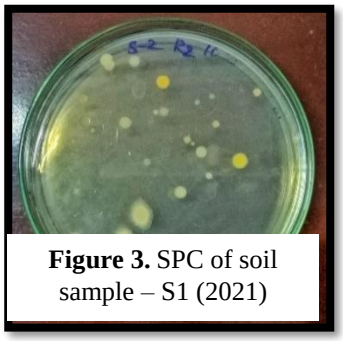

Figure 3. SPC of soil sample – S1 (2021)

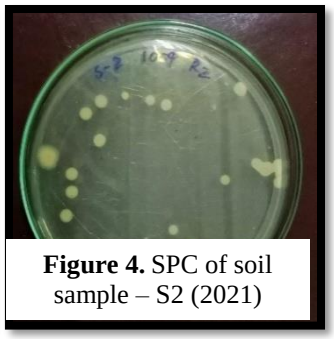

Figure 4. SPC of soil sample – S2 (2021)

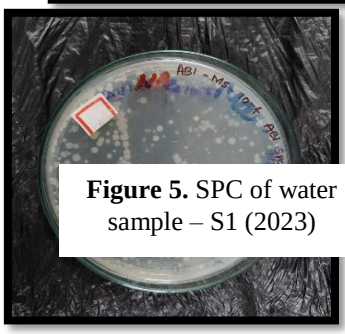

Figure 5. SPC of water sample – S1 (2023)

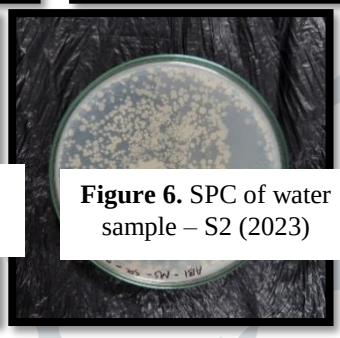

Figure 6. SPC of water sample – S2 (2023)

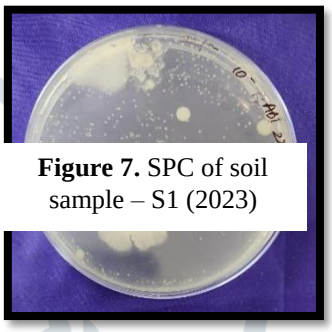

Figure 7. SPC of soil sample – S1 (2023)

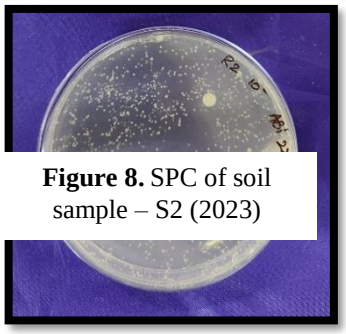

Figure 8. SPC of soil sample – S2 (2023)

3.1Statistical survey

The survey received 215 responses in total over the course of two days, from December 13 to December 15, 2021. Out of 215 respondents, respondents under the age of 20 provided the most responses (16.7%), while respondents above the age of 60 provided the fewest responses (0.5%; **Figure 9**). Female respondents outnumbered male respondents (18.6%) by 80.5% (**Figure 10**).

Of the 215 respondents, 67.9% say Marina is their favorite place to travel, while 32.1% say Tiruchendur is their favorite place to visit (**Figure 11**). 10.2% of the population has visited Tiruchendur more than once, in contrast to 31.6% of the population who have never been there (**Figure 12**). Only 3.3% of the population has never been to Marina, compared to 38.1% of the population who have been there numerous (**Figure 13**). 156 people, or 72.6%, believed that bathing in these resources was improper, but 59 people, or 27.4%, thought it was safe to do so (**Figure 14**). The majority of the people (83.1%) believed that using these resources for bathing had a negative impact on the standard of beaches, whereas the remaining 16.9% did not share this opinion (**Figure 15**). A large percentage of respondents—81.9%, or 176 people—believe that human activity significantly contaminated Marina, while 18.1% said Tiruchendur was more polluted (**Figure 16**).

Out of 215 individuals, 80.9% were aware that they might contract infections from beaches, but the remaining 19.1% were not (**Figure 17**). While 74.4% of the community said they didn't get sick, 25.6% of respondents claimed they became sick after visiting the beaches (**Figure 18**). The majority of respondents (71.2%) chose that the microbial load would be higher on urban beaches than on rural beaches, whereas the remaining 28.8% thought the opposite (**Figure 19**). A whopping 75.3% of respondents said that Marina's water contains more salt than Tiruchendur's, while just 24.7% disagreed (**Figure 20**). Almost half of the population, 45.6%, decided that these waterbodies cannot be made potable, while the remaining 54.4% agreed (**Figure 21**).

The greater part of the respondents, 91.6%, or 197 persons, said that the lockdown and pandemic limitations had enhanced the environmental conditions of the ocean and sand, while 8.4% of respondents experienced no improvement at all (**Figure 22**). The majority of the population (72.6%) suggested that the best way to prevent pollution of these resources with plastic, medico waste, and defecation, while 13.5% selected "Less human intervention" as the best option and another 12.1% chose "using them for productive purposes only" as the more effective choice (**Figure 23**).

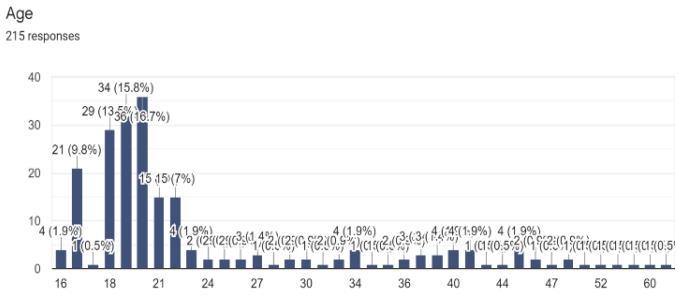

Figure 9. Bar chart representing the age group of respondents.

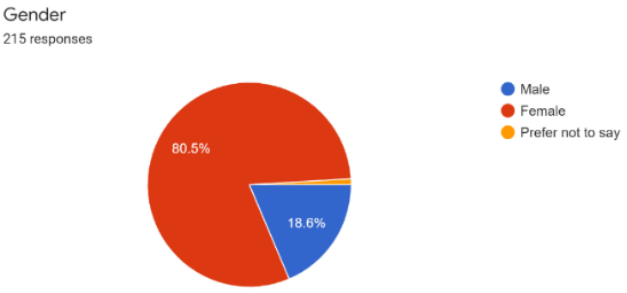

Figure 10. Pie chart representing the gender of the respondents.

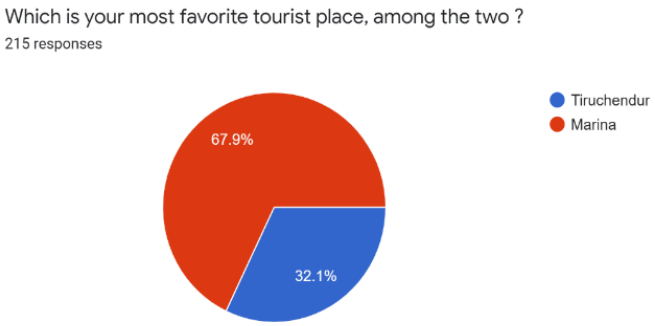

Figure 11. Pie chart representing the respondents favourite tourist place.

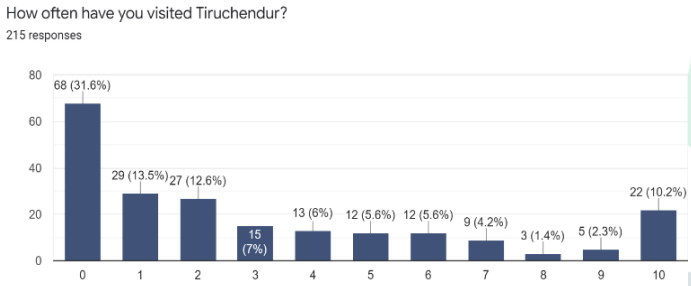

Figure 12. Bar chart representing the respondents visit history of Tiruchendur.

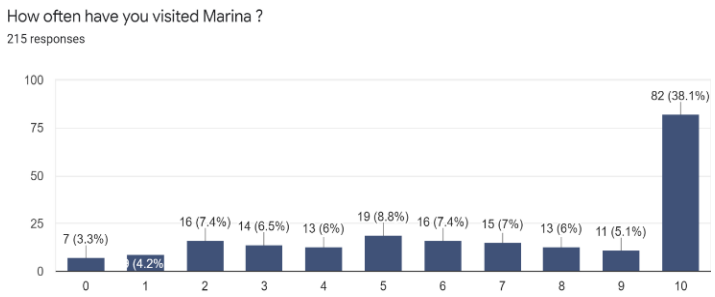

Figure 13. Bar chart representing the respondents visit history of Marina.

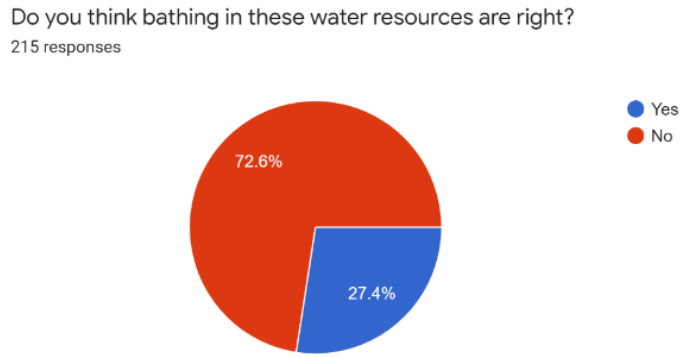

Figure 14. Pie chart representing the respondents view on bathing in water resources.

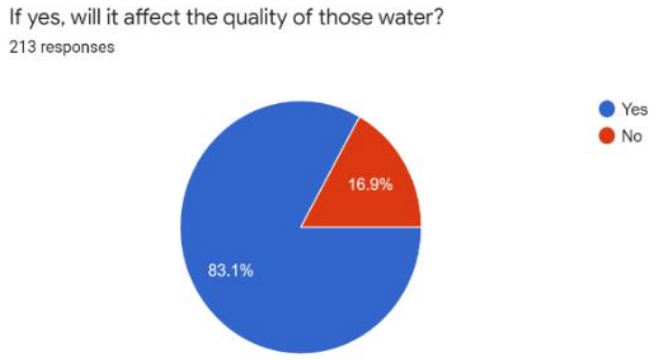

Figure 15. Pie chart describing the view of respondents on the factors affecting quality of beach water.

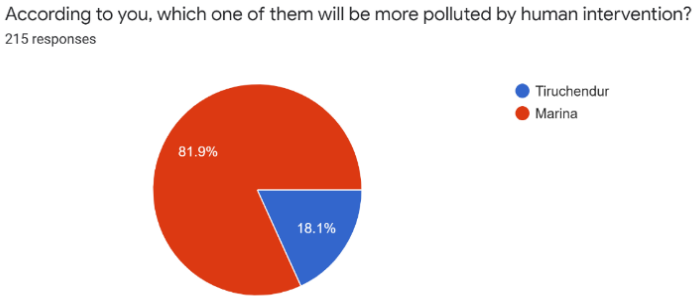

Figure 16. Pie chart representing the respondents view on pollution due to anthropogenic activities.

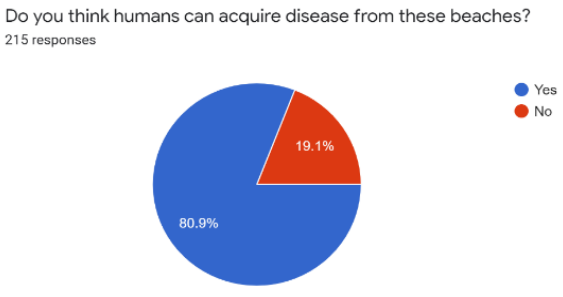

Figure 17. Pie chart representing the respondents awareness on infections spread due to recreational activities in beaches.

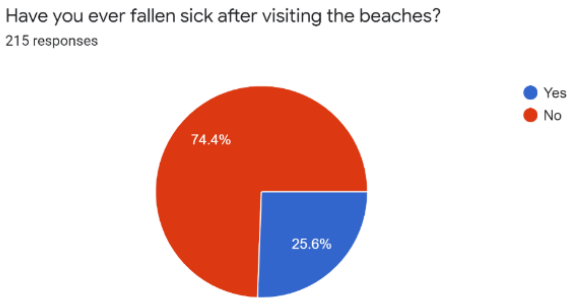

Figure 18. Pie chart representing the health status of respondents after visiting beaches.

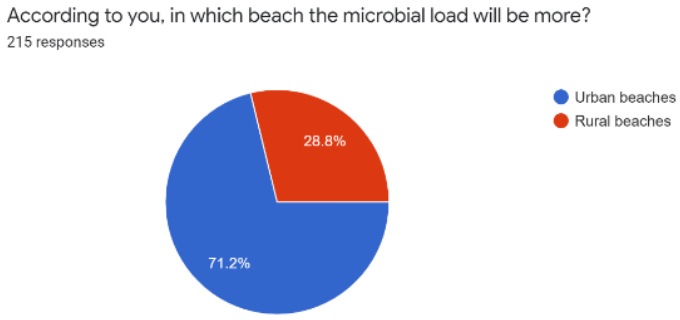

Figure 19. Pie chart representing the respondents awareness on the presence of microorganisms.

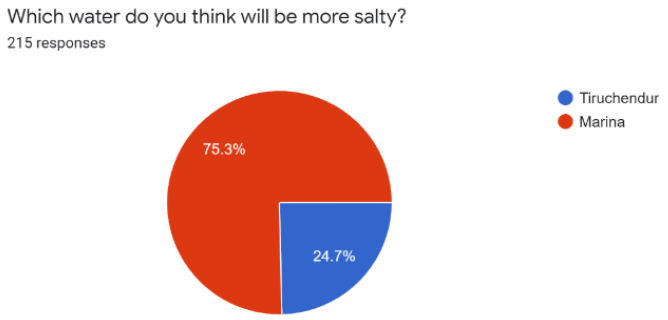

Figure 20. Pie chart representing the respondents view on salt concentration of the beaches.

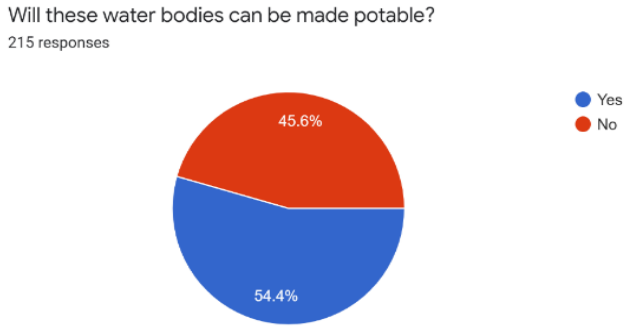

Figure 21. Pie chart representing the respondents view on making the seawater potable.

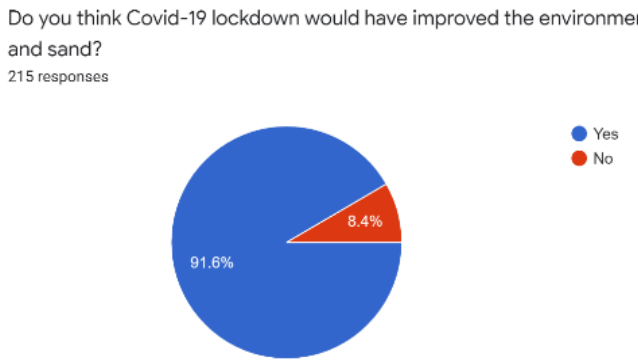

Figure 22. Pie chart representing the respondents awareness on the improvement of environmental condition post-lockdown.

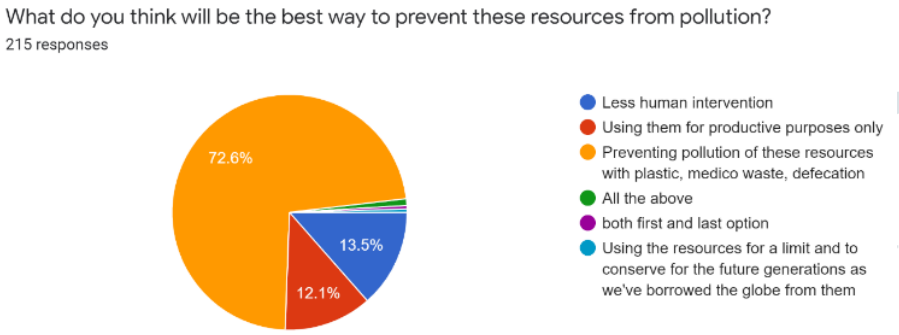

Figure 23. Pie chart representing the respondents awareness of the preventive measures.

IV. DISCUSSION

Tiruchendur and Marina beaches were analysed for various parameters and the results were interpreted. Both soil and water samples had an alkaline pH, however there had been a significant shift in the pH of the soil samples during the two sampling intervals. In a study carried out during the period 2006-2007, the quality of Tiruchendur beach was analyzed and found that the pH of Tiruchendur seawater was differing i.e., 8 (festival days) and 7.4 (normal days) (Ganthi et al., 2009). Similarly, the amount of chloride ion presence in seawater was 24 mg/l, much lesser than the value of chloride obtained during the present analysis. The chlorides, sulphates, organic and inorganic solids content were found to be higher than that of the standard, indicating that they were unfit for various purposes and a substantial reduction in the amount of organic solids present in the water samples was observed in the analysis during the period 2023.

Bacterial counts of water and soil samples were significantly lower in 2021 compared to 2023, signaling changes in human activity due to lockdown restrictions and their subsequent relaxation. The number of bacteria recorded in 2021 were TLTC (S1 & S2) for water samples, 6.55 x10^6 CFU/g (S1) and 6.4 x10^6 CFU/g (S2) for soil samples. In 2023, the samples exhibited bacterial counts of 6.50 x 10^8 CFU/g (S1) and 7.0 x 10^8 CFU/g (S2) for the water samples, and 2.43 x 10^7 (S1) and 2.9 x 10^7 (S2) for the soil samples. These results reveal how the increased population activity has degraded the quality of beaches. Gram positive organisms such as *Staphylococcus*, *Sarcina sp.*, *Micrococcus*, *Enterococcus*, *Corynebacterium*, *Bacillus* were found to be the dominating organisms in seawater. In comparison with seawater, the total coliforms and other Gram-negative organisms such as E. *coli*, *Pseudomonas*, *Aeromonas*, *Acinetobacter* were found to be high in soil sample. The findings also showed that *Aeromonas* counts were high in sand but low in seawater. The presence of *Enterococcus* indicates the contamination by humans. Majority of the organisms isolated were catalase positive, indicating that they were aerobic. The presence of fungi and yeast were also reported in marine water and sand (Kaumadi Samarasekera et al., 2017). Absence of *E. coli* on EMB medium after membrane filtration indicates chances of less contamination of the resources in recent days.

A questionnaire survey consisting of 215 respondents was undertaken to understand beach user's priorities, concern and preferences with regard to their beach use and visit. In general, the results of the survey indicated that majority of the beach users are aware that bathing in the water resources are not right and that these human activities affect the quality of the water. People are also aware that they can acquire diseases from beaches. According to people, urban beaches are highly polluted by human intervention, contains more microbial load and has high salt concentration compared to rural beaches. Majority of the people also feel that environmental conditions of seawater and sand has improved because of the lockdown restrictions and are also aware of the preventive measures to maintain the quality of the water resources.

A survey was conducted across 109 households on beach use and perception of people towards better management in Oman revealed that there was dissatisfaction with regard to provision of service and public would like to see improvement of beaches in this area (Choudri et al., 2016). A study on marine debris pollution along Marina beach was carried out and the results indicated that the plastic, paper and wood debris were found predominantly followed by food waste and metals (Arun Kumar et al., 2016).

In general, in accordance with the lockdown and post-lockdown conditions due to Covid 19 pandemic situation, there were deliberately very less human activity in the beaches, which has led to the reduction in contamination especially the Gram-negative organism's accumulation in the seawater and sands. The environmental conditions have improved a bit temporarily and the water quality has also been increased indicating less contamination and suspended particulate matter. For the first time in Modern times, many of the coastal areas studies has developed features of marine protected areas. Based on recent studies from the southeast coast of India and in Brazil, similar findings have been observed. However, the 2023 investigation revealed a significant microbial load, suggesting heightened pollution as a result of rising population activities.

V. CONCLUSION

Beaches are popular destinations for vacation tourism and leisure activities in many regions of the world. The goal of the current research was to compare and contrast the post-lockdown quality of rural and urban beaches. Various physico-chemical and microbiological characteristics were examined in soil and water samples collected in September, 2021 and August, 2023. The comparison of the soil and water samples revealed that samples from Tiruchendur had significant levels of microorganisms during the first sampling period and samples from Marina had significant amounts of microorganisms during the subsequent study, particularly Gram-positive ones. Compared to samples taken from Marina, Tiruchendur's seawater and sand have a high alkalinity level. In comparison to the Marina sample, the amount of chloride, sulphate, inorganic solids, and organic solids is significantly greater and incredibly high in the Tiruchendur sample. Both samples had the same quantity of suspended matter. The change in chloride levels in Marina water was also a sign that desalination is a practically challenging solution to the city's water demand. The Tiruchendur sample had partially higher levels of pollutants during the initial study because of the sample's increased human activity because of the temple festival, whereas Marina Beach had lower levels of pollutants, probably in compliance with COVID-19 limitations. However, during the second phase of the study, it became apparent that the levels of chlorides, sulphates, and inorganic solids had increased. The prevalence of *E. coli*, a faecal indicator, was not alarming right after the lockdown, suggesting that the resources were not as contaminated, but later in the subsequent year, it was drastically increasing. Results of the questionnaire study indicated awareness among people about the environmental conditions of beaches, the negative effects of bathing, the pollution that humans cause, and potential solutions to these problems.

VI. ACKNOWLEDGMENT

The authors are thankful to the Principal and Faculty of Microbiology Department, Ethiraj College for Women for providing necessary facilities and to carry out this research successfully.

REFERENCES

[1] Ahmad, A., Dada, A. C., Usup, G., and Heng, L. Y. 2013. Validation of the Enterococci indicator for bacteriological quality monitoring of beaches in Malaysia using a multivariate approach. SpringerPlus, 2: 425. https://doi.org/10.1186/2193-1801-2-425

[2] Andraus, S., Pimentel, I.C., and Dionísio, J.A. 2014. Microbiological monitoring of seawater and sand of beaches Matinhos, Caiobá e Guaratuba-PR, Brazil. Estudos de Biologia, 36 (86): 43-55. https://doi.org/10.7213/estud.biol.36.086.AO05

[3] Arun Kumar, A., Sivakumar, R., Y. Sai Rutwik Reddy, Bhagya Raja M.V., Nishanth T., and Revanth V. 2016. Preliminary study on marine debris pollution along Marina beach, Chennai, India. Regional Studies in Marine Science, 5: 35-40. https://doi.org/10.1016/j.rsma.2016.01.002

[4] Choudri, B.S., Mahad Said Baawain, Ahmed Khamis Al Sidairi, Hamed Al-Nadabi, and Khalifa Al-Zeidi. 2016. A Study of Beach Use and Perceptions of People Towards Better Management in Oman. Indian Journal of Geo-Marine Sciences, 45: 1327-1333.

[5] Curiel-Ayala, F., Quiñones-Ramírez, E. I., Pless, R. C., and González-Jasso, E. 2012. Comparative studies on Enterococcus, Clostridium perfringens and Staphylococcus aureus as quality indicators in tropical seawater at a Pacific Mexican beach resort. Marine pollution bulletin, 64(10): 2193–2198. https://doi.org/10.1016/j.marpolbul.2012.07.052

[6] Davies, C.M., Long, J.A., Donald, M., and Ashbolt, N.J. 1995. Survival of fecal microorganisms in marine and freshwater sediments. Appl Environ Microbiol, 61(5): 1888–1896. https://doi.org/10.1128/aem.61.5.1888-1896.1995

[7] DEA. Chapter 9: Oceans and Coasts: Ocean and Coasts Ecosystem Services Are Important as They Directly and Indirectly Impact on Human Livelihoods, Food Security and Agriculture; Oceans and Coasts. Pretoria, South Africa. 2012, pp. 26.

[8] Dibra, H. and Bushati, N. 2023. Microbial indicators of coastal water in Velipoja beach, Albania. Academic Journal of Business, Administration, Law and Social Sciences, 9 (3): 48-53. https://doi.org/10.2478/ajbals-2023-0009

[9] Elmanama, A. A., Fahd, M. I., Afifi, S., Abdallah, S., and Bahr, S. 2005. Microbiological beach sand quality in Gaza Strip in comparison to seawater quality. Environmental research, 99(1): 1–10. https://doi.org/10.1016/j.envres.2004.12.014

[10] Ganthi, A., and Berkmans, S. 2009. An assessment of the quality of water from Tiruchendur temple, Tamil Nadu. Asian Journal of Environmental Science, 4(2): 177-180.

[11] Halliday, E., McLellan, S.L., Amaral-Zettler, L.A., Sogin, M.L., and Gast, R.J. 2014. Comparison of bacterial communities in sands and water at beaches with bacterial water quality violations. PloS one, 9(3), e90815. https://doi.org/10.1371/journal.pone.0090815

[12] Ichsan Rusydi, Irwan Irwan, Sayyid Afdhal El Rahimi, Said Ali Akbar, Karla Amelia, Muhammad Muhammad, Heru Qowiyul Rahman and Imam Safir Alwan Nurza. 2024. Analysis of the levels of pollution in the Ujong Pancu Beach on Physical-Chemical Quality. BIO Web Conferences, 87: 02013. https://doi.org/10.1051/bioconf/20248702013

[13] Kaumadi Samarasekera and Sriyanie Indrika Abeygunawardena. 2017. Microbiology of Seawater and Sand in a Selected Bathing Site of Sri Lanka – A Study Towards Microbial Quality Assessment. Frontiers in Environmental Microbiology, 3(1): 9-18. https://doi.org/10.11648/j.fem.20170301.12

[14] Sabino, R., Rodrigues, R., Costa, I., Carneiro, C., Cunha, M., Duarte, A., Faria, N., Ferreira, F. C., Gargaté, M. J., Júlio, C., Martins, M. L., Nevers, M. B., Oleastro, M., Solo-Gabriele, H., Veríssimo, C., Viegas, C., Whitman, R. L., and Brandão, J. 2014. Routine screening of harmful microorganisms in beach sands: implications to public health. The Science of the total environment, 472: 1062–1069. https://doi.org/10.1016/j.scitotenv.2013.11.091

[15] Velonakis, E., Dimitriadi, D., Papadogiannakis, E., and Vatopoulos, 2014. A. Present status of effect of microorganisms from sand beach on public health. Journal of Coastal Life Medicine, 2: 746-756. http://dx.doi.org/10.12980/JCLM.2.2014JCLM-2014-0067

[16] Zambrano-Monserrate, M.A., Ruano, M.A., and Sanchez-Alcalde, L. 2020. Indirect effects of COVID-19 on the environment. The Science of the total environment, 728: 138813. https://doi.org/10.1016/j.scitotenv.2020.138813