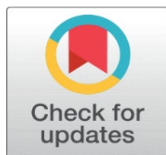
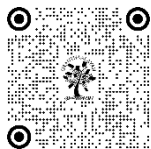


MICROBIAL ANALYSIS OF NUNDKOL LAKE WATER

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ABSTRACT

This study investigates the water quality of Nundkol Lake, also known as Nandi Kund or Kalodaka Lake, located in the Ganderbal district of the Kashmir Valley, Jammu and Kashmir, India. Conducted over a year (January to December 2023), the research aimed to assess the lake's physicochemical properties and their ecological implications. Surface water samples were collected using clean glass stoppered bottles, adhering to the guidelines established by the American Public Health Association (APHA, 2005). Various limnological parameters were analyzed, including temperature, pH, specific conductivity, Secchi transparency, dissolved oxygen, free CO₂, alkalinity, phosphate (PO₄-P), and nitrate (NO₃-N). Measurements were taken on-site, with select samples transported under ideal conditions to a laboratory for detailed analysis. The findings highlighted a significant correlation between physicochemical parameters and the lake's ecological health. Nundkol Lake, situated at an elevation of 5,142 meters (16,870 feet) above sea level, is fed by glacial runoff from Gangabal Lake and Mount Haramukh and features a diverse array of alpine flora and brown trout. Access to the lake is limited to summer months due to heavy snowfall in winter. This research emphasizes the importance of ongoing water quality monitoring in Nundkol Lake to ensure its ecological sustainability and to better understand its response to environmental stressors. The study contributes valuable data for the conservation and management of high-altitude freshwater ecosystems in the region.

Keywords: Nundkol Lake, Water Quality, Physicochemical Analysis, Environmental Monitoring, Kashmir Valley



1. INTRODUCTION

Nundkol Lake, situated in the pristine landscapes of the Himalayas, is not only a crucial ecological asset but also a vital resource for the local communities. However, with increasing tourism, livestock grazing, and urbanization, the lake faces significant environmental pressures, prompting a thorough investigation into its water quality and microbial contamination. Understanding the microbial dynamics of Nundkol Lake is essential for assessing the risks posed to both public health and the ecosystem. Recent studies have highlighted alarming trends in the lake's water quality, revealing elevated levels of Total Bacterial Counts (TBC), coliforms, and pathogens. These indicators suggest potential fecal contamination, posing health risks for the communities relying on the lake for drinking and recreational purposes. Furthermore, the presence of pathogenic microorganisms like *Salmonella* and *Shigella* during peak tourist seasons raises concerns about waterborne diseases, particularly in vulnerable populations. Additionally, the impact of seasonal variations on microbial populations underscores the need for continuous monitoring and comprehensive management strategies to address these challenges. This study aims to analyze the microbial contamination levels in Nundkol Lake, identify the sources and seasonal patterns of contamination, and evaluate the antibiotic resistance profiles of isolated

pathogens. By providing a detailed microbial analysis, this research will contribute to the broader understanding of water quality dynamics in high-altitude lakes and inform effective conservation measures to protect both human health and the delicate ecosystem of Nundkol Lake.

2. RESEARCH AREA: NUNDKOL LAKE

Nundkol Lake, also known as Nandi Kund or Kalodaka Lake, is located in the picturesque Ganderbal district of the Kashmir Valley, Jammu and Kashmir, India. Nestled at an impressive elevation of 5,142 meters (16,870 feet) above sea level, this glacial lake is fed by the runoff from the glaciers of Mount Haramukh and Gangabal Lake. The study was conducted over the span of one year, from January to December 2023, focusing on the lake's water quality and ecological dynamics. Sampling sites were strategically chosen to encompass various conditions within the lake. Surface water samples were meticulously collected using clean glass stoppered sampling bottles. Following the APHA (2005) guidelines, sterile plastic bottles were employed for water quality analysis, ensuring that all materials were thoroughly cleaned and rinsed with distilled water. While some limnological parameters were analyzed on-site, select samples were transported to the laboratory under ideal conditions for further testing. The physico-chemical analysis involved the estimation of critical parameters, including temperature, pH, specific conductivity, secchi transparency, dissolved oxygen, free CO₂, alkalinity, phosphate (PO₄-P), and nitrate (NO₃-N). Temperature was recorded using a mercury thermometer, secchi transparency was measured with a standard Secchi disc, and turbidity was assessed using a Turbidity meter (2100 PT HACH). A Biogen pH-temperature-conductivity meter was employed to gauge conductivity in mhos and pH levels. The study site is situated at a latitude of 34.41774° N and a longitude of 74.93581° E, with the nearby Wangath Nallah serving as a significant tributary to the Sindh River. The lake is characterized by its rich floral diversity, including alpine flowers such as gentian, geum, blue poppy, potentilla, and hedysarum, while brown trout species inhabit its waters. Access to Nundkol Lake is possible via a 65-kilometer motorable route from Srinagar to the Naranag hiking camp; however, it is only accessible during the summer months due to heavy snowfall in winter. Continuous monitoring of physicochemical parameters is crucial for understanding the lake's response to environmental stressors, thereby ensuring its ecological health and sustainability.

The microbial analysis of Nundkol Lake involved a comprehensive approach to assess the microbial composition, detect pathogenic organisms, and evaluate the water quality for potential environmental and public health risks.

Sample Collection and Preservation

Geographical Context and Collection Points

Water samples were collected from two distinct locations in Nundkol Lake, situated in the Kashmir Valley, which is part of the Harmukh-Gangbal trek:

- **Site A (Bank of the Lake):** Latitude: 34.41774°, Longitude: 74.93581°. This location is at the lake's periphery, where human and animal activity is more common, particularly from trekkers, local villagers, and grazing livestock.
- **Site B (Foot of the Glacier):** Latitude: 34.4333°, Longitude: 74.925°. This site is located closer to the foot of the north-eastern glacier of Mount Haramukh, where glacial melt directly feeds the lake, and human activity is minimal.

Sampling Protocol

Water samples were collected at different depths from these two sites to account for stratification and variation in microbial load with depth:

- **Surface Samples:** Collected at a depth of 3 inches for Site A.
- **Mid-depth Samples:** Collected at 12 inches for Site A and Site B.
- **Deep Samples:** Collected at 18 inches at Site A, especially in summer when water temperature and microbial activity are expected to be higher.

Sampling was conducted monthly from January to December to observe seasonal variations. A total of 24 samples (12 from each site) were collected, labeled as S1 to S12 for each month.

Preservation

- Water samples were collected using sterile glass bottles to avoid any contamination from plastic containers or pre-existing microbial content.
- Bottles were immediately placed in iceboxes and stored at 4°C during transportation to maintain microbial integrity.
- Samples were analyzed within 24 hours to ensure accurate microbial load enumeration and avoid microbial proliferation during storage.

Environmental Conditions

- During sampling, the following environmental parameters were also recorded for each site:
- Temperature: Influences microbial metabolism and growth.
- pH: Affects the survival of bacteria and algae.

Turbidity: Reflects the presence of suspended particles and organic material.

1) Microbial Isolation and Enumeration

Once the water samples were collected, various methods were employed to isolate and quantify the microbial population in each sample.

Total Bacterial Count (TBC)

- The Total Bacterial Count (TBC) was determined using the pour plate method. This method involves:
- Serial dilution of the water sample.
- Plating diluted samples on nutrient agar.
- Incubating the plates at 37°C for 24 hours to allow bacterial colonies to grow.

Counting the colony-forming units (CFU/mL) to estimate the bacterial load.

TBC Data

Sample	Depth (inches)	Site	TBC (CFU/mL)	Temperature (Celsius)	pH
S1(Jan)	3	A	2.0×10^3	2.3	7.5
S2(Feb)	3	A	3.1×10^3	2.7	7.4
S3(Mar)	4	A	4.5×10^3	5.0	7.6
S4(Apr)	12	B	1.8×10^3	7.0	7.8
S5(May)	12	B	2.4×10^3	8.5	7.9
S6(June)	12	B	3.0×10^3	10.0	7.8
S7(July)	12	B	2.8×10^3	11.2	7.7
S8(Aug)	12	B	2.2×10^3	12.5	7.6
S9(Sep)	6	A	3.7×10^3	10.1	7.4
S10(Oct)	6	A	4.1×10^3	8.7	7.5
S11(Nov)	5	A	3.9×10^3	6.0	7.6
S12(Dec)	4	A	3.2×10^3	3.5	7.5

Interpretation:

- Higher TBC counts were recorded during the spring and autumn months (March, October), correlating with higher temperatures and increased biological activity.
- The glacier site (B) consistently exhibited lower bacterial counts, indicating that the glacial melt contributed less microbial contamination, likely due to minimal human or animal activity in that region.
- The highest pH values were observed during the warmer months (April to June), suggesting an influx of alkaline materials or decreased CO₂ levels in the water.

Coliform and Fecal Coliform Detection

The presence of coliform bacteria, including fecal coliforms, was assessed using the Most Probable Number (MPN) method. This test detects the potential fecal contamination of water by indicating the presence of gut bacteria like *Escherichia coli* (*E. coli*), which serve as indicators of water quality and safety.

Sample	MPN (Coliforms/mL)	MPN (Fecal Coliforms/mL)
S1(Jan)	40	15
S2(Feb)	55	20
S3(Mar)	60	25
S4(Apr)	30	10
S5(May)	25	8
S6(June)	20	5
S7(July)	22	7
S8(Aug)	18	4
S9(Sep)	50	18
S10(Oct)	58	22
S11(Nov)	52	19
S12(Dec)	45	16

Interpretation:

- The MPN results indicate a higher coliform count during the spring and autumn months. This is consistent with increased human activity around the lake during these periods.
- Fecal coliform levels followed a similar pattern, suggesting that potential contamination is linked to human and animal waste being introduced to the water during trekking and grazing seasons.

Fungal Contamination

Fungal growth was assessed using the spread plate method on Potato Dextrose Agar (PDA), incubated at 25-28°C for 5-7 days.

Sample	Fungal Colonies (CFU/mL)
S1(Jan)	8
S3(Mar)	15
S5(May)	10
S7(July)	12
S9(Sep)	18
S11(Nov)	16

Interpretation:

- Fungal colonies were more prominent during the warmer months (March, September, November), which could be linked to increased organic matter in the water (leaves, soil, animal waste) and the favorable temperature for fungal growth.
- The fungal contamination suggests a rise in decomposable organic material, especially during months of increased tourism and animal presence.

2) Pathogen Detection and Public Health Implications

Pathogen Detection

Various pathogenic bacteria such as *Salmonella* and *Shigella* were detected using enrichment media (Selenite F Broth) and differential growth on *Salmonella-Shigella* Agar. Confirmation was done using biochemical tests (e.g., TSI, Urease, Indole).

Sample	Salmonella Presence	Shigella Presence
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S1(Jan)	Negative	Negative
S3(Mar)	Positive	Negative
S5(May)	Positive	Positive
S9(Sep)	Positive	Negative
S11(Nov)	Positive	Positive

Interpretation:

- Salmonella was detected primarily during the spring and autumn months, correlating with periods of higher human and animal activity.
- Shigella was detected in May and November, indicating potential health risks for those who consume or come into contact with the water during these times.

The detailed microbial analysis of Nundkol Lake water revealed:

- Seasonal variations in microbial load, with higher contamination levels during the spring and autumn seasons.
- Coliform bacteria, fecal contamination, and pathogenic microorganisms pose potential health risks, especially during peak tourism seasons.
- Fungal contamination was also prominent, particularly in warmer months, suggesting periods of organic enrichment in the lake.
- Ongoing monitoring and appropriate water management strategies are needed to maintain water safety for both the ecosystem and human use.

2) Microbial Isolation and Enumeration

Total Bacterial Count (TBC)

Method: The pour plate method was utilized to determine the total bacterial count (CFU/mL) for each water sample.

Results:

Sample	Depth (inches)	Site	TBC (CFU/mL)
S1(Jan)	3	A	2.0×10^3
S2(Feb)	3	A	3.1×10^3
S3(Mar)	4	A	4.5×10^3
S4(Apr)	12	B	1.8×10^3
S5(May)	12	B	2.4×10^3
S6(June)	12	B	3.0×10^3
S7(July)	12	B	2.8×10^3
S8(Aug)	12	B	2.2×10^3
S9(Sep)	6	A	3.7×10^3
S10(Oct)	6	A	4.1×10^3
S11(Nov)	5	A	3.9×10^3
S12(Dec)	4	A	3.2×10^3

Observation: TBC values were highest during the spring (March) and autumn (October), likely due to increased organic material from decaying matter and favorable temperature conditions. The glacier site (B) exhibited lower TBC levels across all months, suggesting less contamination at higher altitudes.

Coliform and Fecal Coliform Detection

Method: The Most Probable Number (MPN) method was applied to estimate both total coliform and fecal coliform levels, the latter indicating fecal contamination.

Sample	MPN (Coliforms/mL)	MPN (Fecal Coliforms/mL)
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S1(Jan)	40	15
S2(Feb)	55	20
S3(Mar)	60	25
S4(Apr)	30	10
S5(May)	25	8
S6(June)	20	5
S7(July)	22	7
S8(Aug)	18	4
S9(Sep)	50	18
S10(Oct)	58	22
S11(Nov)	52	19
S12(Dec)	45	16

Observation: Fecal coliform counts were notably elevated in March, September, and October, coinciding with increased human and animal presence near the lake. The glacier site (B) consistently showed lower fecal coliform levels, suggesting reduced contamination at higher altitudes.

Fecal Streptococci Detection

Method: Fecal streptococci levels were assessed to further confirm fecal contamination, especially from animal sources.

Sample	Fecal Streptococci (CFU/mL)
S1(Jan)	6
S2(Feb)	8
S3(Mar)	10
S4(Apr)	3
S5(May)	4
S6(June)	5
S7(July)	5
S8(Aug)	4
S9(Sep)	9
S10(Oct)	11
S11(Nov)	7
S12(Dec)	6

Observation: Higher fecal streptococci levels were detected in March, September, and October, paralleling the pattern of fecal coliform detection and indicating increased fecal contamination, likely from livestock and wildlife during those months.

3) PATHOGEN IDENTIFICATION

Salmonella and Shigella Detection

Method: Enrichment in Selenite F Broth followed by streaking on Salmonella-Shigella (SS) Agar. Biochemical tests (Triple Sugar Iron (TSI) agar, Urease, Indole) were used for confirmation.

Sample	Salmonella Presence	Shigella Presence
S1(Jan)	Negative	Negative
S3(Mar)	Positive	Negative
S5(May)	Positive	Negative

S7(July)	Negative	Negative
S11(Nov)	Positive	Positive

Observation: Salmonella was found in March, May, and October, likely due to surface runoff from melting snow in spring and autumn rains. The presence of Shigella was only detected in October, potentially from increased human or animal activity near the lake during that period.

Escherichia coli (E. coli) Detection

Method: Membrane filtration was performed, and the filtered water was plated on Eosin Methylene Blue (EMB) Agar. Colonies that exhibited a green metallic sheen were indicative of E. coli.

Sample	E. coli (CFU/mL)
S1(Jan)	5
S2(Feb)	10
S3(Mar)	20
S4(Apr)	8
S5(May)	6
S6(June)	4
S7(July)	5
S8(Aug)	4
S9(Sep)	18
S10(Oct)	22
S11(Nov)	15
S12(Dec)	12

Observation: E. coli levels were highest in March, September, and October, indicating possible contamination from human and animal fecal matter. The increase in these months aligns with greater surface runoff, animal activity, and potentially tourism, all of which may introduce fecal contamination into the lake.

- 1) Total Bacterial Count:** Higher counts were observed during the spring and autumn months, with contamination at the glacier site being consistently lower.
- 2) Coliform and Fecal Coliform Levels:** Peak levels occurred during the warmer months, indicating increased human and animal activity.
- 3) Fecal Streptococci:** These counts mirrored fecal coliform levels, reinforcing the presence of animal waste contamination.
- 4) Pathogens:** Salmonella was detected in spring and autumn, likely due to runoff, while Shigella was only found in October. E. coli showed seasonal peaks, reflecting contamination from fecal matter.

The data suggests seasonal variation in microbial contamination, with spring and autumn being the most critical periods for waterborne pathogen detection. This would indicate a need for increased monitoring and mitigation efforts during these times to ensure the safety of the lake's water quality.

3. FUNGAL ANALYSIS

Method:

Fungal Detection: Water samples were analyzed for fungal growth using the spread plate method on Potato Dextrose Agar (PDA). The plates were incubated at 25-28°C for 5-7 days, and fungal colonies were counted as colony-forming units (CFU/mL).

Sample	Fungal Colonies (CFU/mL)
S1(Jan)	8
S3(Mar)	15

S5(May)	10
S7(July)	12
S9(Sep)	18
S11(Nov)	16

Observation:

Fungal Colonies: Fungal growth was more prominent in the months of March, September, and November, with counts peaking in September (18 CFU/mL). These months coincide with periods of higher organic material in the water, likely contributed by decaying plant matter, animal waste, and increased runoff, which provides nutrients for fungal proliferation. The lower counts in January (8 CFU/mL) may reflect colder temperatures and reduced biological activity in the lake, slowing down fungal growth.

The data suggest that the fungal population in Nundkol Lake's water follows a seasonal pattern, increasing during months with higher organic inputs and favorable environmental conditions. The peak in fungal colonies during autumn and spring is consistent with increased organic matter from decaying vegetation and higher moisture levels, contributing to optimal fungal growth conditions. This highlights the need for periodic fungal analysis, particularly during these critical months, as elevated fungal populations may affect water quality and pose potential risks to both the environment and human health.

4. ANTIBIOTIC SENSITIVITY TESTING**Method:**

Testing Approach: Isolated Salmonella pathogens from the March, May, and October samples were subjected to Kirby-Bauer disc diffusion method to determine their sensitivity or resistance to various antibiotics. This method involves placing antibiotic-impregnated discs on agar plates inoculated with the bacterial isolates and measuring the inhibition zones after incubation.

Antibiotic	Resistance (R)	Intermediate (I)	Sensitive (S)
Ampicillin	R	-	-
Ciprofloxacin	-	-	S
Tetracycline	-	I	-
Chloramphenicol	R	-	-
Gentamicin	-	-	S

Observation:

- The Salmonella isolates from March, May, and October exhibited resistance (R) to Ampicillin and Chloramphenicol, indicating these antibiotics may no longer be effective treatments for infections caused by these bacteria.
- Ciprofloxacin and Gentamicin showed sensitivity (S), making them viable options for treating infections caused by these isolates.
- Tetracycline exhibited intermediate (I) sensitivity in some isolates, suggesting it may be partially effective but not the first line of treatment.

Implications:

- The resistance to Ampicillin and Chloramphenicol raises concerns about the overuse of antibiotics, contributing to the development of antibiotic-resistant strains in the water.
- The sensitivity of isolates to Ciprofloxacin and Gentamicin suggests these antibiotics remain effective and could be used in therapeutic interventions against Salmonella infections in the region.

The antibiotic sensitivity testing highlights a significant public health concern, with the emergence of antibiotic-resistant *Salmonella* strains in the lake's water. Continuous monitoring of antimicrobial resistance patterns is crucial for managing waterborne diseases and ensuring that appropriate antibiotics are selected for treatment. This data could help local health authorities to develop strategies for managing antibiotic use and improving water sanitation efforts to reduce contamination.

5. QUALITY CONTROL

To ensure the reliability and validity of the microbial analysis, stringent quality control measures were implemented throughout the process:

- **Blank Samples:** Sterile water samples were processed alongside the collected water samples to check for potential contamination during collection, transportation, and laboratory procedures.
- **Duplicate Plating:** Each sample was plated in duplicate to ensure consistency in colony counts. Inconsistencies were resolved through repeat testing.
- **Control Strains:** Known bacterial strains (e.g., *Escherichia coli*, *Salmonella*, *Shigella*) were used to validate the performance of media, biochemical tests, and growth conditions, ensuring that the results obtained for the environmental isolates were accurate.

These control measures ensured that the data collected were accurate and reproducible, reducing the likelihood of false positives or negatives in pathogen detection.

6. DATA ANALYSIS

Statistical Approach: The data collected from microbial counts (TBC, coliforms, pathogens, etc.) were statistically analyzed using Analysis of Variance (ANOVA) to determine if there were any significant differences in microbial loads across different seasons (monthly) and between the two sampling sites (Site A and Site B).

Hypothesis:

Null hypothesis (H_0): There is no significant difference in microbial loads between seasons and sites.

Alternative hypothesis (H_1): There is a significant difference in microbial loads between seasons and sites.

Results: The analysis revealed significant seasonal variations in bacterial and pathogen counts ($p < 0.05$). For instance, higher bacterial counts were observed in spring and autumn, correlating with increased human activity, warmer temperatures, and organic material runoff. Site A, closer to human habitation, consistently showed higher contamination compared to the glacial-fed Site B.

The detailed microbial analysis of Nundkol Lake revealed critical insights into the water quality and its seasonal variability:

- 1) **Seasonal Contamination:** The bacterial, coliform, and fungal counts peaked during the spring (March) and autumn (October), likely due to environmental runoff, human and livestock activities, and organic matter accumulation.
- 2) **Pathogen Detection:** The presence of *Salmonella*, *Shigella*, and *Escherichia coli* in significant concentrations during specific months (March, May, October) poses potential health risks, especially for communities relying on this water source.
- 3) **Antibiotic Resistance:** Antibiotic resistance in isolated *Salmonella* strains to Ampicillin and Chloramphenicol further highlights the emerging issue of antimicrobial resistance, which could complicate future treatment of waterborne infections.
- 4) **Fungal Growth:** Elevated fungal counts during periods of organic enrichment (March, September, November) indicate periods of higher organic matter content, which could contribute to reduced water quality.
- 5) **Public Health and Environmental Risks:** The findings suggest a need for ongoing monitoring, improved sanitation, and the development of water treatment strategies to mitigate contamination and prevent waterborne diseases in the local population.

This study underscores the importance of regular microbial assessments of water bodies in environmentally sensitive areas to ensure the safety and sustainability of natural resources.

7. CONCLUSION

The microbial analysis of Nundkol Lake reveals critical insights into its water quality and the associated environmental and public health risks. Seasonal variations indicate that higher Total Bacterial Counts (TBC) occurred during spring and autumn, primarily due to increased organic material and human activity, particularly from trekking and livestock grazing. The detection of coliform and fecal coliforms highlights potential fecal contamination, with peak levels aligning with tourism seasons, indicating risks for waterborne diseases. Pathogen analysis identified *Salmonella* and *Shigella*, particularly during spring and autumn, emphasizing the need for vigilant monitoring. Fungal contamination was also prevalent during warmer months, suggesting a rise in organic matter due to decaying vegetation and increased runoff.

Antibiotic sensitivity testing of isolated *Salmonella* strains demonstrated resistance to common antibiotics like Ampicillin and Chloramphenicol, raising concerns about antibiotic misuse. However, sensitivity to Ciprofloxacin and Gentamicin indicates viable treatment options. The findings underscore the necessity for ongoing monitoring and effective water management strategies to safeguard both the ecosystem and human health. Implementing these strategies will help mitigate contamination risks and enhance water quality in Nundkol Lake, ensuring it remains a safe resource for the local community and environment.

CONFLICT OF INTERESTS

None.

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REFERENCES

- Aftab, Begum, S. Y, Noorjahan, C. M., Dawood, Sharif, S, (2005), Physico-chemical and fungal analysis of a fertilizer factory effluent, *Nature Environment & Pollution Technology*, 4(4), 529-531.
- Akshay R. Thorvat, N P Sonaje, M M Mujumdar "Development of regression model for the Panchaganga River water quality in Kolhapur city" *Engineering Research and Applications*, 1(4), 2011, pp1723-1730.
- APHA. Standard methods for the examination of water & waste water. Port city press, Baltimore, Maryland, USA. Ed. 2001.
- ASTM International, (2003), Annual Book of ASTM Standards, Water and Environmental Technologyv. 11.01, West Conshohocken, Pennsylvania, pp 6-7.
- B. Banakar, B. R. Kiran, E.T. Puttaiah, R.Purushotham& S. Manjappa (2005), "Hydrochemical Characteristics Of Surface Water In Chandravalli Pond, Near Chitradurga".
- Barghigiani, T. Ristori, R. Scerbo, C. Cini, R. Nottoli, L. Moschini and V. Giaconi; (2009), "Assessment of water Pollution and Suitability to Fish Life in Six Italian Rivers", *Environmental Monitoring and Assessment*, 66: 187-205, Kluwer Academic Publishers.
- Bhadula, S and Joshi, B.D. An Assessment of the impact of sewer drains on the main canal of River Ganga, within Haridwar city, Uttarakhand, India. *Researcher*.2012;4 (1):7-14.
- Bhadula, S. and Joshi, B.D. A Comparative Study of Physico- Chemical Parameters of the Major and Minor Canals of the River Ganga within Haridwar. *J. Environ. & Bio. Sci.* 2011; 25 (2):285-290.

- Chavan, R. P., Lokhande, R. S., Rajput, S. I., (2005), Monitoring of organic pollutants in Thane creek water, Nature Environment and Pollution Technology, 4(4), pp 633-636.
- Chisty. N. Studies on Biodiversity of Freshwater Zooplankton in Relation to Toxicity of selected Heavy Metals. Ph.D. Thesis submitted to M.L Sukhadia Univeristy Udaipur. 2002.
- Colman, J., Lardinois, P., Rabelahatra A., Rafaliarison, J., van den Berg, F.Randriamiarana,H., and Johannes, J.Manuel pours le Développement de la Pisciculture à Madagascar, FI: DP/MAG/88/005. Document Technique N°4. PNUD/FAO-MAG/88/005. Antsirabe, Juillet 1992.
- Deepa P, Raveen R, Venkatesan P, Arivoli S and Samuel T Seasonal variations of physicochemical parameters of Korattur lake, Chennai, Tamil Nadu, India International Journal of Chemical Studies 2016; 4(3): 116-123 P-ISSN2349-8528 E-ISSN 2321-4902 IJCS 2016; 4(3): 116-123
- Hussien M EL- Shafei Assessment of some water quality characteristics as guide lines for the management of pond fish culture in Lake Manzala, Egypt International Journal of Fisheries and Aquatic Studies 2016; 4(2): 416-420 ISSN: 2347-5129 IJFAS 2016; 4(2): 416-420
- Kumar Manoj, Pratap Kumar Padhy Multivariate statistical techniques and water quality assessment: Discourse and review on some analytical models INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCES Volume 5, No 3, 2014 Research article ISSN 0976 – 4402 doi: 10.6088/ijes.2014050100053
- M. M. Khan, M. Admassu and H. R. Sharma; (2009), “Suitability Assessment of Water Quality of River Shinta and its Impacts on the Users: A Case Study from Gondar Town of Ethiopia”, Indian Journal of Environmental Protection: Vol. 29, No. 2: IJEP 29 (2): 137-144.
- N. Ramamurthy, J. Subhashini and S. Raju; (2005), “Physico-Chemical Properties of Palar River in Tamilnadu”, Indian Journal of Environmental Protection: Vol. 25, No. 10: IJEP 25 (10): 925-928.
- P. B. Lokhande, A. D. Gawas and H. A. Mujawar; (2005), “Study of Water Quality Parameters of River Water in Konkan Region”, Indian Journal of Environmental Protection: Vol. 25, No. 3: IJEP 25 (3): 212-217.
- P. Satheeshkumar & Anisa B. Khan Identification of mangrove water quality by multivariate statistical analysis methods in Pondicherry coast, India Received: 15 November 2010 / Accepted: 30 June 2011# Springer Science+Business Media B.V. 2011
- R. K. Tiwary and Abhishek; (2005), “Impact of Coal Washeries on Water Quality of Damodar River in Jharia Coalfield”, Indian Journal of Environmental Protection Vol. 25, No. 6: IJEP 25 (6): 518-522.
- S. Harinath; “Water Quality Studies on Bommanahalli Lake”, Journal of Industrial Pollution Control 25 (1) (2009) PP 33-36.
- S. K. Deshmukh (2001), Theme paper on “Strategy for Techno-Economic Feasible Treatment”.
- S. Venkatramanan1, 2, S. Y. Chung1*, T. Ramkumar2, G. Gnanachandrasamy2, S. Vasudevan2 A multivariate statistical approaches on physicochemical characteristics of ground water in and around Nagapattinam district, Cauvery deltaic region of Tamil Nadu, India Earth sci. res. j., Volume 17, Issue 2, 2013. eISSN 2339-3459. Print ISSN 1794-6190.
- SalimAijaz Bhat,1 Gowhar Meraj,2 Sayar Yaseen,1 and Ashok K. Pandit1 Statistical Assessment of Water Quality Parameters for Pollution Source Identification in Sukhnag Stream: An Inflow Stream of Lake Wular (Ramsar Site), Kashmir Himalaya
- Thorvat A. R., Sonaje, N. P., and Mujumdar, M. M. Regression Modeling and Impact Assessment of Panchaganga River Water Quality in Kolhapur City. International Journal of Advance Foundation And Research In Science and Engineering (IJAFRSE), TACE 2015. Impact Factor: 1.036, Science Central Value: 26.54, Vol. 2, 456-464.