IMPACT OF ANTHROPOGENIC ACTIVITIES ON RIVER HEALTH: A STUDY OF RIVER NARMADA AND SONE

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Impact of Anthropogenic Activities on River Health: A Study of River Narmada and Sone

by

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Dedicated to

MOTHER (RIVER) NARMADA

and

My Mother (Smt. Rashmi Sapre)

Inspired by

Late Shri Anil Madhav Dave

In Loving Memory of

My Father (Late Shri Shirish Sapre)

and

My Grandparents (Late Smt. Vijaya & Late Shri Vasant Sapre and Late Shri Arvind Potnis)

With Gratitude to

My Wife (Smt. Arpita Sapre) & Daughter (Ku. Medini Sapre)

CERTIFICATE

This is to certify that the thesis entitled **"Impact of Anthropogenic Activities on River Health: A Study of Narmada & Sone"**, submitted by **Kartik Shirish Sapre** to the Indian Institute of Technology Delhi, for the award of the degree of **Doctor of Philosophy**, is a record of the original, bona fide research work carried out by him under our supervision and guidance. The thesis has reached the standards fulfilling the requirements of the regulations related to the award of the degree.

The results contained in this thesis have not been submitted in part or in full to any other University or Institute for the award of any degree or diploma to the best of our knowledge.

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(Kartik Shirish Sapre)

ABSTRACT

Rivers are perceived as living entities in Indian philosophy of life and is seen holistically that integrate social, cultural, biological, environmental and geographical dimensions. However, over the past few decades, this equilibrium has been disrupted as society increasingly views natural resources, including rivers, from a utilitarian perspective. This shift has led to significant ecological consequences, adversely impacting river ecosystems, including biodiversity, agriculture, indigenous cultural practices, and livelihoods.

Similar to human physiology, the various components of a river function collectively to maintain their own health and contribute to the overall well-being of the river system. However, if this ecological balance is neglected, the river ecosystem may deteriorate. Ensuring the sustainability of a river requires maintaining the integrity of its system. This necessitates a comprehensive understanding of key factors such as water quantity and quality, societal interactions, industrial and chemical agricultural impacts, illegal mining activities, deforestation, aquatic ecosystems, and biodiversity conservation.

This research study examined river system health and sustainability through a holistic approach, incorporating an analysis of existing policy frameworks alongside a review of relevant literature. A comprehensive framework was developed by integrating diverse aspects, synthesizing available information, and consulting subject matter experts. The framework was structured using the Pressure-State-Response (PSR) approach, encompassing hydrological, environmental, socio-economic, and policy indicators. It incorporates indicators related to livelihoods, cultural and religious practices, tourism, and governance, with a central focus on the river system. Additionally, key hydrological and environmental parameters were integrated to ensure a comprehensive understanding of river sustainability.

To conduct a detailed analysis, Amarkantak, the source region of the Narmada and Sone rivers, was selected as the study area. Satellite data was utilized to examine the river catchment, enabling a comprehensive assessment of changes occurring in the region over the past two decades. These observations were systematically verified through cross-examination. Additionally, executive, legislative, and judicial documents relevant to the Amarkantak region were reviewed and incorporated into the study following consultations with relevant authorities and subject matter experts.

This study revealed a significant decline in water bodies and sources within the catchment area, with a reduction of 31%. Additionally, dense forest cover decreased by 35%, while Sal mixed forest declined by 36%. A notable reduction in medicinal plant populations with ~47% nearly extinct and 37% endangered, along with reduced moisture levels, was also recorded in the Amarkantak region. Furthermore, groundwater levels have declined, and the water quality of the Narmada River was assessed using a water quality index based on a seven-year dataset from three locations: the origin (55.84), Pushkar reservoir (68.89), and Kapil Dhara (65.28). A comparative analysis of data from 2016-17 and 2022-23 indicates a slight improvement in water quality at the source (47.99), whereas a decline was observed at the other two locations. Additionally, the environmental pressure index has increased by 156% over the past two decades.

The study observed a significant accumulation of waste, including plastic, in the Amarkantak region, coinciding with a rise in tourism and visitor influx in recent years. Historically, bauxite mining has had a substantial impact on the area both environmentally and economically. Presently, 62% local livelihoods are predominantly dependent on religious, spiritual, and eco-tourism, 21% on agriculture and 17% on other activities. The region faces critical challenges related to drinking water availability and solid-liquid waste management. Additionally, Amarkantak holds ecological significance as a biodiversity hotspot, the origin of two major Indian rivers, and a prominent religious and spiritual centre, necessitating focused conservation efforts.

The developed framework facilitated a holistic assessment of water and environmental issues, along with societal and governmental aspects. It enabled a comprehensive understanding of the anthropogenic impacts on the river catchment area. The findings and insights were compiled and presented to the Madhya Pradesh and Central Government, aiding policymakers in making informed decisions regarding the conservation and sustainable management of Amarkantak. This research framework has the potential for further expansion and can serve as a valuable tool for sustaining river systems across the country in the future.

सार

भारतीय परम्परा एवं जीवनशैली में नदी को एक सम्पूर्ण इकाई के रूप में देखा गया है। नदियाँ अपने में सामाजिक, सांस्कृतिक, जैविक एवं भोगौलिक परिवेश को समाहित करते हुए एक जीवन तंत्र बनाती है। विगत कुछ दशकों से इस जीवन तंत्र की लय टूटने लगी है, जब से समाज ने प्राकृतिक संसाधनों एवं नदियों को उपभोक्ता की नजर से देखना शुरू किया है। जिसके कारण नदियों का पारिस्थितिकी तंत्र, जिसमें जैव-विविधता, कृषि, लोक संस्कृति, आजीविका शामिल हैं, सभी बुरी तरह प्रभावित हो रहे हैं।

मनुष्य की ही तरह, नदी के विभिन्न अंग स्वयं को स्वस्थ रखने के लिए काम करते हैं और पूरी नदी को स्वस्थ बनाए रखने में मदद करते हैं। परंतु अगर नदियों के इस पारिस्थितिकी तंत्र की ओर ध्यान ना दिया जाए तो वह भी बीमार हो सकती है। अतः नदी की सततता बनाये रखने हेतु उसके तंत्र का स्वस्थ रहना आवश्यक है। जिस हेतु हमें इसके विभिन्न पहलू जैसे जल की मात्र एवं गुणवत्ता, समाज का व्यवहार, उद्योगों व रासायनिक कृषि से हो रहे दुष्परिणाम, अवैध खनन, वन घनत्व में कमी, जलीय जीवन, जैव-विविधता इत्यादि को समझना आवश्यक है।

इस शोध कार्य में स्वस्थ नदी तंत्र एवं उसकी वहनीयता की दृष्टि से एवं उसे समग्रता में देखने के लिए अध्ययन किया गया जिसमें उपलब्ध साहित्य की समीक्षा के साथ ही मौजूदा नीति नियमों को भी समझने का प्रयास किया गया। विभिन्न पहलुओं को जानने, उपलब्ध जानकारियों एवं विशेषज्ञों से चर्चा कर एक रूपरेखा/फ्रेमवर्क तैयार की गई। इस रूप रेखा को हाइड्रोलॉजी, एनवायरनमेंट, लाइफ एवं पालिसी पक्षों पर प्रेशर स्टेट एंड रिपॉन्स एप्रोच का प्रयोग कर तैयार किया गया। जिसमें प्रमुखता से जीवनशैली के विभिन्न पक्षों, नीतिगत विषयों के साथ आजीविका, सांस्कृतिक, धार्मिक, पर्यटन, इत्यादि पक्षों को जोड़ा गया और जल विज्ञान से जुड़े और पर्यावरण संबंधित कुछ बिंदुओं को समाहित कर नदी तंत्र को केंद्र में रखते हुए समग्र स्वरूप में लाने का प्रयास किया गया।

इस कार्य को विस्तार से समझने हेतु नर्मदा एवं सोन नदी के उद्गम स्थान, अमरकंटक का चयन किया गया। नदी के जलग्रहण को उपग्रह डेटा के माध्यम से समझने उपरांत उसमें आ रहे परिवर्तन को व्यापक रूप से जानेने एवं उसके प्रतिपरीक्षण कर सत्यापित करने की दृष्टि से चयनित क्षत्रे अमरकंटक में पिछले २ दशकों में हुए परिवर्तन का अध्ययन किया गया। साथी ही अमरकंटक क्षेत्र से संबंधित कार्यकारी, विधायी एवं न्यायिक दस्ताविजों को भी देखा गया और संबंधित अधिकारियों एवं विषय विशेषज्ञों से चर्चा उपरांत इन्हें भी समाहित किया गया।

इस अध्ययन के दौरान यह ध्यान में आया की जलग्रहण क्षेत्र/वाटरशेड में जल निकायों/स्रोतों में ३१% से कमी आई, साथ ही, सघन वन ३५% कम हुआ है और साल मिश्रित वन जंगल ३६% से कम हुआ। साथ ही अमरकंटक क्षेत्र में औषधीय पौधे कम हुए हैं, वन घनत्व एवं नामी में कमी दर्ज की गई है। साथ ही भूमिगत जल में गिरावट के साथ नर्मदा जल की गुणवत्ता हेतु ३ स्थानों पर ७ वर्षों के उपलब्ध डेटा पर किए जल गुणवत्ता सूचकांक अनुसार उद्गम (५५.८४), पुष्कर जलाशय (६८.८९) और कपिल धारा (६५.२८)। २०१६-१७ के आंकड़ों को अगर २०२३ से तुलना करने पर यह ध्यान आया कि उद्गम पर (४७.९९) गुणवत्ता में थोड़ा सुधार हुआ है एवं शेष दोनों स्थानों में गिरावट हुई है। इन्हीं सब के साथ २० वर्षों में पर्यावरणीय दबाव सूचकांक १५६% पाया गया है।

अमरकंटक क्षेत्र में कचरा, प्लास्टिक इत्यादि काफ़ी मात्र में देखा गया, साथ ही विगत वर्षों में यहाँ पर्यटकों और आने-जाने वाले लोगों में वृद्धि हुई है। वर्तमान में, 62% स्थानीय आजीविका मुख्य रूप से धार्मिक, आध्यात्मिक और पर्यावरण पर्यटन पर निर्भर है, 21% कृषि पर और 17% अन्य गतिविधियों पर निर्भर है। पूर्व में बाक्साइट की खदानों का इस स्थान पर आर्थिक एवं पर्यावरणीय, दोनों ही रूप में काफ़ी प्रभाव रहा है। आजीविका के लिए वर्तमान निर्भरता अधिकतम धार्मिक-आध्यात्मिक एवं इको-टूरिज्म पर है। इस क्षेत्र में पेय जल एवं ठोस-तरल अपशिष्ट प्रबंधन की महती आवश्तकता है। साथ ही अमरकंटक क्षेत्र जैवविविधता, भारत की दो बड़ी प्रमुख नादियों के उद्गम और धार्मिक-आध्यात्मिक केंद्र की दृष्टि से एक महत्वपूर्ण स्थान है। जिसके संरक्षण की आवश्यकता है।

इस फ्रेमवर्क से जल एवं पर्यावरण के साथ ही समाज एवं सरकार से जुड़े विषयों को समग्रता से देखा जा सका। साथ नदी जलग्रहण क्षेत्र पर मानवजनित गतिविधियों से हो रहे प्रभावों को समग्र रूप से समझा जा सका। विभिन्न पहलुओं और परिणामों को संकलित कर मध्य प्रदेश एवं केंद्र शासन को साझा किया गया जिससे नीति निर्धारकों को अमरकंटक के परिपेक्ष्य में व्यापक रूप से चिंता करने एवं यधोचित निर्णय लेने में सुविधा हुई। इस कार्य को और विस्तारित किया जा सकता है एवं देश में वहनीय नदी तंत्र बनाये रखने हेतु उपयोगी साबित होगा।

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LIST OF ABBREVIATIONS

1. **AG:** Agriculture
2. **BOD:** Biological Oxygen Demand
3. **CCMEWQI:** Canadian Council of Ministers of the Environment Water Quality Index
4. **CGWA:** Central Ground Water Authority
5. **CGWB:** Central Ground Water Board
6. **COD:** Chemical Oxygen Demand
7. **CWC:** Central Water Commission
8. **CWSI:** Canadian Water Sustainability Index
9. **DBU:** Designated Best Use
10. **DMF:** Dense Mixed Forest
11. **DO:** Dissolved Oxygen
12. **EC:** Environmental Clearance
13. **EHI:** Ecological Health Index
14. **EPI:** Environmental Pressure Index
15. **EQI:** Ecological Quality Index
16. **FC:** Forest Clearance
17. **GIS:** Geographic Information System
18. **HB:** Habitation
19. **IRF:** International River Foundation
20. **IWRIS:** India Water Resource Information System
21. **LULC:** Land Use Land Cover
22. **MPCST:** Madhya Pradesh Council of Science & Technology
23. **MPDPR:** Madhya Pradesh Directorate of Public Relations
24. **MPPCB:** Madhya Pradesh Pollution Control Board
25. **MPWRD:** Madhya Pradesh Water Resources Department
26. **MSS:** Multi-Spectral Scanner
27. **NIE:** National Institute of Ecology
28. **NIH:** National Institute of Hydrology
29. **NRCD:** National River Conservation Directorate
30. **NRHI:** Narmada River Health Index

31. OECD: Organisation for Economic Cooperation and Development

32. OIP: Overall Index for Pollution

33. OMF: Other Mixed Forest

34. PHRI: People's River Health Index

35. PIB: Press Information Bureau

36. PIL: Public Interest Litigation

37. PSR: Press State Response

38. RH: River Health

39. RHA: River Health Assessment

40. RHC: River Health Condition

41. RHI: River Health Index

42. RPI: River Pollution Index

43. SDGs: Sustainable Development Goals

44. SMF: Sal Mixed Forest

45. SWM: Sustainable Water Management

46. TC: Total Coliform

47. TDS: Total Dissolved Solid

48. TN: Total Nitrogen

49. TP: Total Phosphate

50. TS: Total Solid

51. UNECE: United Nations Economic Commission for Europe

52. UNESCO: United Nations Educational, Scientific and Cultural Organization

53. USEPA: United States Environmental Protection Agency

54. WAWQI: Weighted Arithmetic Water Quality Index

55. WFPI: Water Footprint Index

56. WJWSI: West Java Water Sustainability Index

57. WPI: Water Poverty Index

58. WQI: Water Quality Index

59. WRD: Water Resources Department

60. WSI: Watershed Sustainability Index

61. WWAP: World Water Assessment Programme

62. WWF: World Wide Fund for Nature