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A qualitative analysis of water from the forested catchments- with special reference to bamboo forested catchment

Hari Shanker Gupta

Institute of Forest Productivity (ICFRE) Ranchi, Jharkhand, India, 834005

Abstract

Forested watersheds are sinks for nutrients and atmospheric pollutants, trapping them before it enters streams. The forest floor also acts as filters that prevent sedimentation to streams and consistently help produce lower turbidity and suspended solid loads. The impact of forest on water quality largely depends on the species composition, forest patchlocation within the watershed etc., though it has not been studied much in the Jharkhand,India.

The study highlights positive link between forests types/density and the quality of water coming out of the forested catchment, with variable link between water quality and "composition of forest" or "density of forest" explored. "Forest type" and its effect on water quality is analyzed.

Keywords Bamboo; Catchment; Forest type; Forest density in catchment, India; Jharkhand; Land cover; Land use; Quality of water

Corresponding author: Hari Shanker Gupta, Institute of Forest Productivity (ICFRE) Ranchi, Jharkhand, India, 834005

1. Introduction

The global economy, with expanding human activity has ever increasing water demand for multiple purposes. Withonly 7% of the water beingusable fresh water resource and much of it originating from forested catchments, the 30% of the area of land under forest play critical roles, particularly in maintenance of water quality (Fulton and West 2002). The term “water quality” generally means the chemical, physical and biological characteristics, usually for its suitability for adifferent use. Forested watersheds are sinks for nutrients and atmospheric pollutants, trapping them before it enters streams. Important determinants of the chemistry of surface waters flowing from forest are climatic patterns, environmental conditions affecting plant communities, terrestrial biological processes, soil characteristics and geological weathering etc., but the impact of forest on water quality largely depends on the forest patch location within the watershed and on the species composition, Variability in chemical and physical constituents subsequently affects biological water quality etc. (FAO 2007), though it is not explored much. This is important to consider, as this natural variability is the baseline from which the regulation of activities that affect water quality can be judged and managed (Parimala and Elango 2013).

The forest floor also acts as filters that prevent sedimentation to streams (Neary et al. 2009), and consistently help produce lower turbidity and suspended solid loads (Pike et al. 2010). At many scales and across much geography, Watersheds with more land under forest tend to have better water quality (Morse et al. 2018). Another study shows that following wildfire, increased erosion rates and changes to runoff generation and pollutant sources may greatly increase fluxes of sediment, nutrients and other water quality constituents (Smith et al. 2010). Yet another study found trees and ground vegetation in forest ecosystems slows water movement and help stabilize soil. Prevention or reduction of soil erosion helps reduce sedimentation type pollution in streams, rivers and lakes (Schira 2016). Another study applies a straightforward multivariate approach for quantifying forest cover effects on nine physico-chemical water quality variables, inferring that forest cover explains about one third of the variability of water quality and is positively correlated with higher quality water and when controlling for spatial autocorrelation, forest cover still explains 9% of water quality (Delphine et al. 2017).

One research shows that forest areas have a positive effect on the balance of most substances dissolved in water, and natural factors in many cases shape the quality and utility values of surface waters on an equal footing with anthropogenic factors. In the case of a large number of

examined parameters and complex processes occurring, the interpretation of the results makes it much easier by applying multivariate statistical methods (Bogdal et al. 2019). A study by Duffy et al. (2020) infers a positive impact from forest cover on water quality over the time periods examined and undisturbed forest cover is a preferable land use option relative to more seasonal land use practices. Its findings offer a deeper insight into the impacts of afforestation and forest cover make over a meaningful time frame that is not available in site specific studies. Trenčiansky et al. (2021) have observed differences in surface runoff between forest- and non-forest catchments and the existence of the forest as such excludes ornoticeably eliminates the use of fertilizers and chemical substances that affect water quality. In another study, Shah et al. (2022) found, Sediment delivery is the most significant water quality impact of forest management, these impacts are usually short-term but long-term impacts also occur and that necessitates BMPs can reduce and prevent water quality impacts.

There appears to be a clear link between forests and the quality of water coming out of a forested catchment, but the variable link between water quality and "composition of forest" or "density of forest" has notbeen studied in local context. Knowledge of the "forest type/density"and its effect on water quality as also perceivedto be beneficial by local tribals, but this linkage was yet to be studied and hence analyzed in this study.

Objectives of Study

This analysis is for assessing water qualitydownstream of water harvesting structures (which have been regularly constructed by state Forest Department in large number under CAMPA or State Plan) with objective to provide water for human/animal consumption, irrigation and reducing soil erosion in catchment, recharging of surrounding wells through percolation of water etc. The study attempts to assess efficacy and effectivenessof stated objectiveVs outcome.

a. To assess the comparative properties of water of water-bodies, constructed in catchment forest of different composition and different densities, in order to assess this variability; for further public policy interventions.

b. To find the correlation ship pattern between the "water quality" and "Forest type" and "forest density".

c. High light the role of "Bamboo Forest" on quality of runoff; with specific perception of related ecology of indigenous community.

2. Materials and Methods

2.1. Study area

The Jharkhand state (India) which has a geographical area of 79,714 km², with total recorded forest area of 23,605 km² (which is 29.61% of the geographical area) is chosen for the study.

Table 1. Major Forest types of Jharkhand

Sl. No.	Forest types	Name of forest types	Acronym used in the study
1	3C/C2e	Moist Deciduous Sal Forest	MDS
2	5B/C1c	Dry Peninsular Sal Forest	DPS
3	5B/C2	Northern Dry Mixed Deciduous Forest	NDMD
4	5/DS1	Dry Deciduous Scrub	DDS
5	5/E9	Bamboo Brakes	BB

2.2. Sampling

For assessing water quality samples from randomly chosen 210 sites (for each WH Structures) were taken, spread over 26 Forest Divisions of Jharkhand. Sites were selected to encompass major variety of “Forest Types” and “Forest Density” of statebetween period of September 2017-April 2018. Samples were analyzed for 13 parameters (covering physical, chemical and biological characteristics) of water quality.

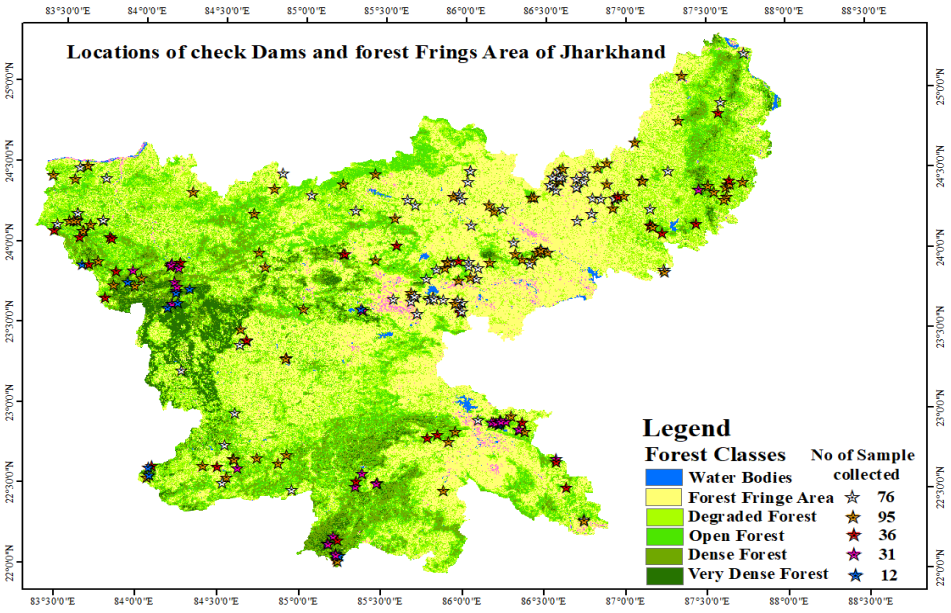

Fig. 1. Map showing location of Sample Site in forest of different Density in Jharkhand

2.3. Laboratory Analysis

The pre-treatment and the qualitative determination of the parameters were done in the State Geological Laboratory, following the National Standard methods.

Spatial analysis was done using the ARC GIS software for analyzing catchment area, “Forest Type” and “Forest Density” features.

3. Results and Discussion

Out of 210 water samples collected from the Water harvesting structures in 26 Forest Divisions, 40% have been found suitable for drinking purpose (83 water samples), 124 water sample or 59% have been found fit for irrigation purposes. Only 3 water samples were found not usable for drinking purposesandnor for irrigation purpose. Thus, majority of the samples have been found having good water quality from forested catchment.

The pH of water is found slightly acidic, but within the permissible limits both for potable and irrigation purpose. The iron content of water has been observed with very less variability ,with mean value of 0.35.the iron content is at the lower level of the permissible limit which indicates the importance of human and associated process on forest floor or beneath surface; affecting the quality of water through runoff .The iron content of water in both analysis is at the lower of the permissible limit which indicates the importance of humus and litter content inside the forest canopy affecting percolation of water through various soil horizons. Increased alkalinity as well as pH of the samples indicate good water quality as these parameters have direct positive impact on water. The mean value of Nitrate content of water is 0.44, with the S.D. of 0.54 indicating lesser variability among various Forest Types/density. Large variability is noticed in *E. coli* content samples, which can be possiblyattributed to large biotic interference insome of the forested watershed. The mean value of TDS content is 169.61. The TDS value was found higher in samples from watershed in Dry Deciduous Scrub and with decreasing value in to Bamboo Brakes Forest Type. This indicates that the “Bamboo Brakes Forest” have capacity for moderating the TDS value which is an important desirable parameter of water for drinking, cooking and for other domestic purposes. From the “Path Analysis” was inferred that three water quality parameters such as turbidity, iron content, *E. coli* content have highly detrimental impact on water quality,meaning thereby that watersheds having higher value of these three parameters

have lower water quality and vice–versa. However, pH and alkalinity of water is the favorable indicator of improved water quality parameters.

From the study, mean and standard deviation value of the 12 water parameters indicate that- two parameter i.e. residual chloride content and *E. coli* in water is on higher side than the permissible limit with large deviation among water samples. However, remaining ten water parameters showed satisfactory performance with little or moderate standard deviation.

3.1. Inferences, on quality of water from the catchment having different Forest Types

However, variability in quality of water is noticed, indicating significant influence of different forest types on water quality.

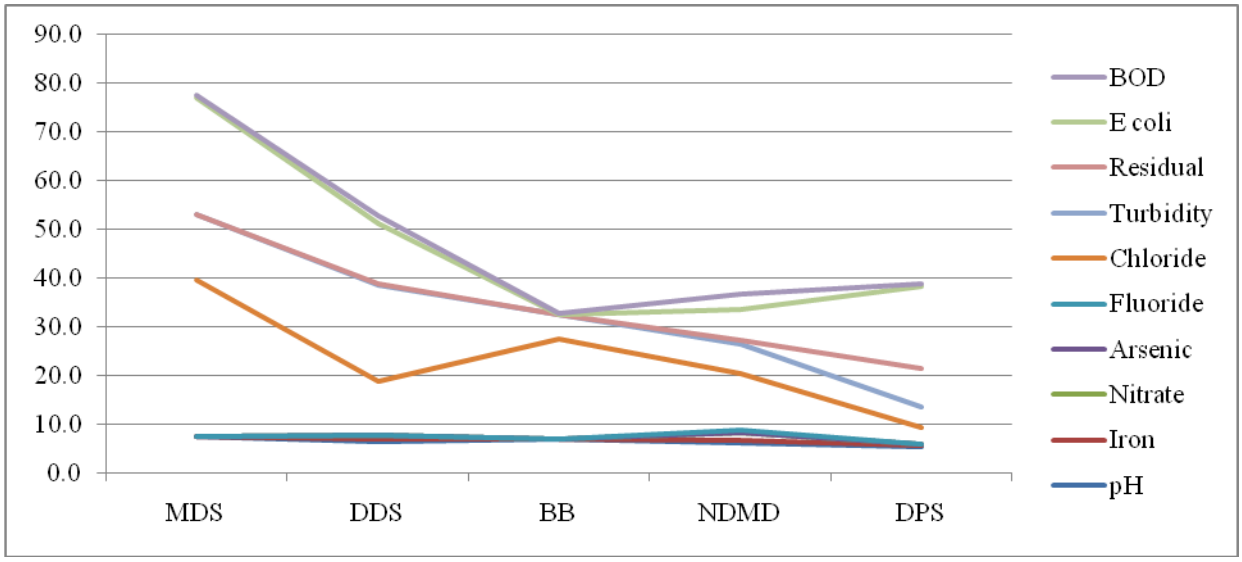

Fig. 2. Water quality variation, catchments with different forest types

The Fig. (2) depicts the variation of water quality parameters, for catchment having different forest types. It can be inferred that water quality in “Dry Peninsular Sal Forest” has better water quality in comparison to “Northern Dry Mixed Deciduous Forest”, “Bamboo Brakes” and “Dry Deciduous Scrub Forest” types, in reducing order. The result of water quality from “Bamboo brake forest” has a very interesting link to the prevailing local perceptionof local tribals also.

The village Tebolies in a typical valley of Porahatregion in Singhbhum district. “Ho”, a typical indigenous community that Shas been living in this region for thousands of years. The area had rich Bamboo Forest in its upstream catchment, till 50 years ago. The tract in question has predominantly “Bamboo Forest”, but in late 1960s- it witnessed the “gregarious flowering of bamboo” and that coincided with “extreme drought” too. This combined with poor management

resulted into “Bamboo regeneration” led to no or very poor regeneration of bamboos. The fallout was the eradication of “Bamboo” and “Sal Forest” intruded in this tractas its replacement. In the last 5 decades, this compositional change has affected many components of environment. This change; as observed by the local “Ho” community is quite vivid; when they tell that earlier the runoff from the “bamboo forest” used to be better for their paddy crop and all the elements like mollusc etc. in water bodies were bigger in size and number as compared to their reduced safe and faunal number. The river “Hirni” and its tributaries are witness to this change in water quality and its effect on fauna. As the village elders of the area reminisces that in earlier time the size and quantity of freshwater Mollusc was in were of much bigger size more than what is available now. They tell that not only the size of mollusc etc. and their number has got reduced but the yield of paddy is also getting poor, compared to the days when their forest was full of bamboo. The reason identified is that Bamboo Forest runoff has higher alkalinity, Hardness and Chloride content which has links to the size and number of molluscs in fresh water bodies (Brian Rooke et al. 1983). In this study, the sample of water tested from bamboo forest has shown difference in quality with water flowing from the “Sal Forest”. The “lower ph.” is one important factor; which has been found responsible for large size and number of molluscs etc. in flowing water. This observation of general perception of the community is vindicated and validated by the scientific study available.

3.2. Inferences on, Water quality from the catchment with different Forest Density

This analysis of water quality variation with respect to Forest density in agreement with the universal theory that denser forest cover has better quality of water. Conversely the quality of water deteriorates, as one moves from “Very dense forest” type to “Forest Fringe Area”. This trend confirms; that the “forestdensity” has positive effect on quality.

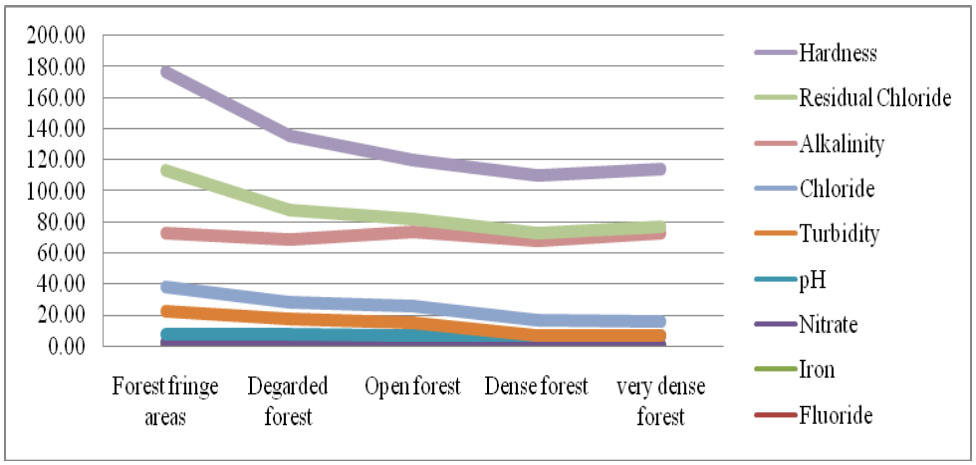

Fig. 3. Water quality in different forest density catchment

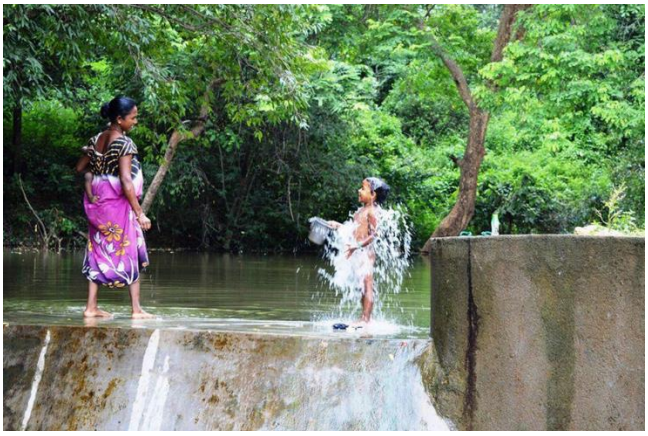

Fig. 4. A photograph of Water Harvesting structure and catchment forest in the background

Conclusion

In present study, out of the total collected samples 40% were found suitable for drinking purpose and 59% for irrigation purpose. It also inferred that all the parameters with some exceptions are under the permissible limit as per the BIS standard are also under the permissible limit for Class-A and Class-D category of CPCB. The water quality studyshows thatboth “forest types” and “forest density” of catchment area has significant influence on water quality. The “trend” of “Forest type” v/s water quality in the context of Jharkhand is very interesting and this offers different opportunities to put appropriate “value” to the ecosystem-services fordifferent “forest types” in more objective and utilitarian manner. The water from catchments with “Open”/“Forest Fringe Area” have relatively poorer water quality, which improves to the highest value in the “Dense and Very Dense Forest cover”; which is the other end of the continuum as shown in fig. – 2. The study also suggests that forest types also prominently play a role in deciding the water quality emanating from it. The analysis and interpretation of the study shows its usefulness; in the context of various SDGs, particularly Goal 6

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Conflict of Interest

It is hereby confirmed that the manuscript has been read and approved by all the named authors and there is no conflict of interest. All regulations of our institution/institute/company including intellectual property rights have been followed and there are no impediments to publication.

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