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Research Article

Study of Physico-Chemical Status for Augmentation of Kamvari River Flow and Restoration of Water Quality in Bhiwandi City (MS)

Snehal S Donde*

Dean Administrative Affairs, BhaktivedantaVidyapeetha Research Centre, India

***Corresponding Author:** Snehal S Donde, Dean Administrative Affairs, BhaktivedantaVidyapeetha Research Centre, India.

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Abstract

Kamvari river was once a huge commercial navigation port, is now a diminishing perennial river of total 34 Km length flowing polluted through the Bhiwandi city, Kalyan Taluka, Maharashtra. Researcher being a Jalnayak recognized by Government of Maharashtra has taken initiative to revive and rejuvenate the river Kamvari along with other water bodies to restore its historic glory. The aim is to make all water bodies pollution free. Thus, origin to confluence of river course was located with Google Earth app and remote sensing images and documented for first time the origin in Depoli and Lamaj village and confluence in Thane creek, ultimately draining in Arabian sea. The investigation of point and non-point sources of pollution, showed the establishment of most of the Textile Units, Slaughter houses and Tabelas in blue line area of river and direct release of untreated effluents from these sources along with untreated sewage water in the river. Water samples of river and other water bodies across Bhiwandi city was collected from multiple sites with intercept method, were subjected to Physico-chemical parameters tests. Almost status of all parameters in every sample was against the permissible limits and indicated percolation and mixing of creak water in ground water, among other factors. Respondents response during social assessment was very crucial to understand the rising pollution issues and risk to human health. Low capacity Sewage Treatment Plants (28%), no or non- functional Effluents Treatment Plants (ETP) in textile units, solid waste disposal in water bodies, power-looms without toilets need immediate action. An integrated approach working model has been recommended to the administrative authorities in Bhiwandi region and District Collector office to work in tandem for revival of water bodies with appropriate restoration plans.

Keywords: Water Bodies; Physico-Chemical Parameters; Industry Pollution; River Restoration

Introduction

Ancient scriptures and religious books mention how civilization grew on banks of river, as it supported nourishment and livelihood for the human life. Rivers always had crucial role in the Indian History. Along their banks the ancient residential regions lead to the birth of great cities. The boons showered by the Indus and her tributaries on the Punjab (The Land of the Five Rivers) and the nourishing waters of the Great Ganges paved a path for the growth of Indo-Gangetic plain. Yamuna, Saraswati, Brahmaputra, Godavari, Bhima, Kaveri, Narmada, Beas, Tapti, Jhelum, etc. are few major rivers of India, for thousands of years, supported the teeming population of India which has cultivated the fertile valleys. Rivers were considered as mother as it had a nature of giving. Its resources, rich biodiversity and use for transportation altogether provided foundations for advancements in civilization. Influential villages and cities such as Hastinapur, Prayag, and Patliputra were situated on the banks of the rivers. There are many cities and villages which are flourished by the grace of the rivers, rivulets and tributaries flowing through them. Similarly, Bhiwandi city in Thane District of Maharashtra also came into existence and flourished as it was a busy commercial navigation port in 16th Century and later developed into Textile and Logistics Industrial hub. However, in the name of modernization, urbanization and with consumerism, the river infrastructure is destructed, shrunken and polluted. Same is the condition of rivers and other water bodies in Bhiwandi region.

In Thane district of Maharashtra, Bhiwandi taluka is rich with its landscape of Western Ghats and is blessed with water supply from Tansa, Bhatsa, Ulhas and Kamvari rivers. There are also many water bodies such as Varala Lake, Narpoli Lake, Diwan Shah Lake, Bhadwad Lake, Shelar Lake, Kalher Lake, Purna Lake, Khoni Lake, KoparLake, etc. According to the census of 2011, the total population of the Bhiwandi taluka was 1,141,386 out of which urban population is 863,740 while rural is 277,646 [4]. Overall Bhiwandi taluka is under administration of Bhiwandi Nizampur City Municipal Corporation (BNCMC) in city area and rural region is under the jurisdiction of Gram Panchayat Samiti and the Mumbai Metropolitan Regional Development Authority (MMRDA) [21,34,35]. For pollution regulation, Maharashtra Pollution Control Board (MPCB) of Kalyan region is the authority. Overall jurisdiction is under control of Collector Thane District. Bhiwandi receives about 2722 mm of rainfall annually[15]. Average ground water level in Bhiwandi taluka is 1.10m. This city receives daily 20 million litres (MLD) water. There are more than 5 lakhs power looms, 225 plus dyeing, printing, processing units in Bhiwandi and therefore it is also called “Manchester of India”. However, the flip side is that as there is huge demand of water supply to these units for processing and washing, pollution of Kamvari river and other water bodies are rampant.

Present study was undertaken to locate the complete river course of Kamvari and water bodies to identify the point and non-point sources of pollution, with the primary objectives of recommending restoration plan. Bhiwandi has tremendous potential in terms of economic growth and providing livelihood to many. However, since a decade this city is facing severe water scarcity, ground water pollution, as Kamwari River is diminishing or dried at many spots as well as other water bodies are seen filled with solid waste disposals. This study was also felt necessary due to the fact that even though the world is covered with 70% of water, only 2.5% of it is fresh water and maximum is saline and ocean-based. In essence, only 0.007% of the earth’s water is available to fuel and feed its people[24]. For conservation of this fraction of freshwater, there is urgent need to conserve rivers and freshwater bodies. In Indian scenario, although some attention has been drawn towards major rivers which have religious sentiments, but there are many water bodies which remain neglected due to lack of such sentiments. Kamwari River flowing across Bhiwandi is one such river which is heavily polluted by the effluents of textile companies having dyeing and sizing units, Tabeles and slaughter houses established on its bank. This river was once upon a time a busy port, is now shrunken drastically at many places along its stretch. The present exploratory study was designed to understand the current pollution status of Kamwari River and other water bodies through the physico-chemical parameters and generate sets of data base for submitting to authorities to take appropriate action for revivals.

Research Methodology

Exploratory research method was applied to the study for finding original source of Kamvari river through google satellite images and Remote sensing images available on Government information site. To identify point and non-point sources of River and other water bodies researcher physically visited the place. The water samples were collected by intercept method (Figure 2 and 3) from Kamvari River and other water bodies (Figure4) and transported to lab as specified by protocol. Physico-chemical parameters of water samples were analysed in Central Glass and Ceramics Research Institute, Kolkata. The pH was measured using digital pH meter with an accuracy of +0.01. For social mapping detailed interviews were conducted with locals, to generate perceptions towards pollution of water bodies and health risks.

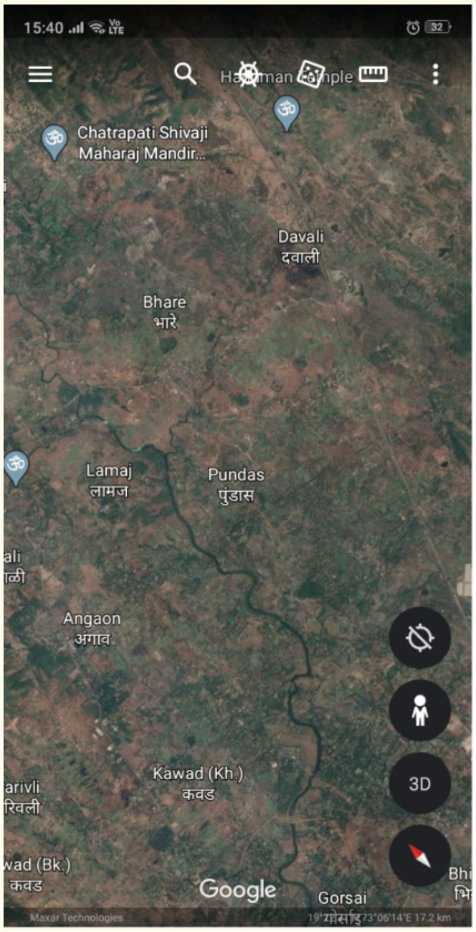

Figure 1: Administrative jurisdiction in Bhiwandi(White region – Municipal Corporation, Rest of the region-MMRDA and Gram Panchayat Samiti).

Figure 2: Tilak Ghat, Kamwari River (Site 1): 19°18'52.1"N 73°03'52.8"E.

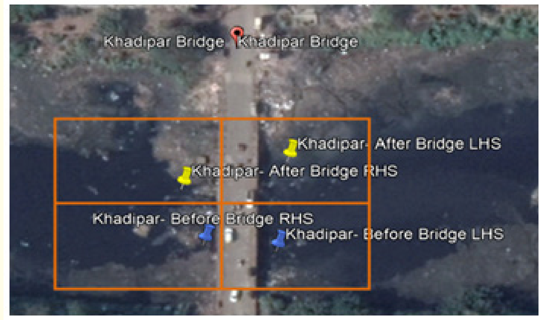

Figure 3: Khadipar area, Kamwari River (Site 2): 19°18'25.4"N 73°03'12.5"E.

Kopar Lake Bhadwad Lake Rahnal Lake

Varala Lake Purna Lake Diwanshah Lake

Narpoli Lake

Figure 4: Lake Water samples collection sites in Bhiwandi region.

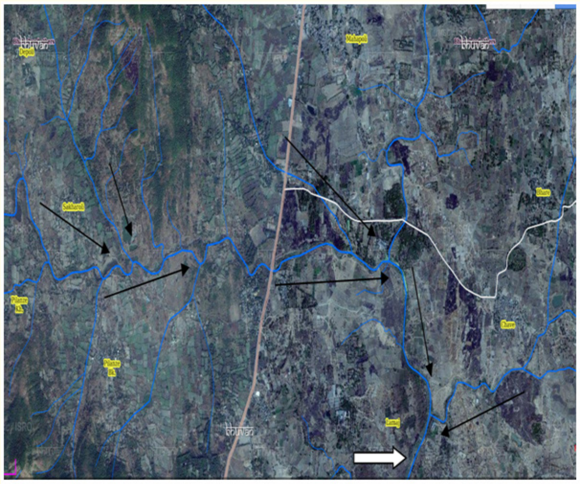

Figure 5: Origin of Kamwari River(Arrows indicate formation of Kamwari river from mountain streams).

Figure 6: Water theft and Water mafia in action at Kamwari River.

Figure 7: Status of various lakes in Bhiwandi.

Figure 8: Status of Kamwari River in Bhiwandi.

Results andDiscussion

Exploration study of Kamvari river in connectivity to Ghodbunder region in Thane City enroute to Bhiwandi and Mohalla bunder area in Bhiwandi city, revealed history in context to 16th Century Kamvari which was a commercial navigational port for horse trade from Italy and France in exchange of spices supply from Bhiwandi. Gradually, city flourished commercially with power looms, Textile sizing units and other companies which were shifted in 1995 from Mumbai city due to issues of Trade Unions. Later in 2004, Textile dying companies from Ulhasnagar region shifted to Bhiwandi. Establishment of several ware houses and Cattle sheds (Tabela) came up with demand of tea stalls by factory workers. Slaughter houses (Katalkhana) and Tabelas are constructed encroaching river lands. The establishment of industries has led to dense urbanization and area expanded towards Bhiwandi in the east along the Central Railway line on one side and across the thane creek. The population of Bhiwandi swell from 70,000 to 11 lakhs as per the census of year 2011. However, in the process of development the unchecked and uncontrolled direct release of waste water and textile units solid waste and effluents into the river has caused great environmental impact. All over the place river and water bodies are found covered by plastics, textile garbage and emanating foul smell.

While exploring the Kamvari River source it was found that the river stream originates from hills near Depoli, Lamaj and Pundas villages in the form of multiple short streams. The total stretch of Kamwari River is 33.75 km which passes through villages such as Sakhroli, Pundas, Lamaj, Kawad, Shelar, Khoni, and main Bhiwandi city and finally it empties into the Thane creek.

Point sources of Kamwari pollution were seen at Shelar, Khoni, Katai and Savandhe villages. Similarly, the non-point sources could be seen very prominently in residential complex in Oswalwadi, Narpoli region, etc where the effluents were release in nallahs in the area. Point sources of Kamwari River at Tilak Ghat region is visible near the Nadi Naka Bridge, at Khadipar area the sources are mainly power looms, few sizing units, sewage, heated water, etc. Pollution of Varala Lake is mainly due to washing of vehicles and clothes, immersion of religious idols, dumping of religious floral waste, throwing of solid waste, etc. At Diwanshah Lake regular dumping of slaughter house waste, washing of animals in lake, washing vehicles, etc are sources of pollution. The release of untreated effluents from dying, sizing units of textiles, power looms and other factories and also the sludge from Sewage Treatment Plants (STP) are common in the areas such as Sawandhe, Katai and Khoni (dense industrial zones). The detailed Physico-chemical analysis with status and impact of excess limits of every factor is specified in the table below.

Physico-chemical parameters of water bodies in bhiwandi											
Site of sample collection	Turbidity (NTU)	pH	TDS (mg/l)	EC (µs/cm)	Salinity (ppm)	F (mg/l)	Cl (mg/l)	Br (mg/l)	NO_3 (mg/l)	PO_4 (mg/l)	SO_4 (mg/l)
Kamwari (Tilak Ghat)	125.96	7.22	1120	1793.8	0.62	0.66	422.95	2.88	N.D.	38.86	19.49
Kamwari (Khadipar)	14.39	7.37	1917	3095.5	1.53	0.59	754.81	1.53	N.D.	98.11	48.79
Bhadwad Lake	20.95	7.30	1186	1917	0.915	0.645	78.44	0.3	N.D.	661.06	317.18
Kopar Lake	2.25	8.03	732	1186	0.555	0.185	540.01	0.5	0.57	122.04	65.07
Purna Lake	7.17	7.32	572	9289	0.43	0.92	416.35	0.14	2.97	113.2	58.19
Varala Lake	2.775	7.45	258.5	274	0.19	0.715	32.85	6.66	N.D.	44.50	25.06
Diwanshah Lake	6.99	7.38	383.5	618.5	0.28	0.16	59.25	6.79	N.D.	24.93	12.52
Rahnal Lake	60.76	7.42	659	1044	13.21	3.745	341.95	931	0.42	115.73	114.45
Kalher Lake	14.2	7.58	1137	1837	0.88	0.6	461.03	0.27	N.D.	105.78	59.7
Narpoli Lake	7.98	7.50	479.5	782	0.36	0.29	58.52	0.51	N.D.	626.25	317.25
Acceptable limits	5.00	6.5-8.5	500	1500	-	1	250	-	45	0.5	200

Table 1: Physico-chemical analysis of samples collected from Kamwari River and other water bodies in Bhiwandi.

*NTU: Nephelometric Turbidity Unit.

Table 1 shows the physico-chemical analysis of Kamwari River at both sites, Diwan Shah Lake, Bhadwad Lake, Shelar Lake, Kalher Lake, Purna Lake, Khoni Lake, and Kopar Lake. The data indicates the highly polluted condition of all water bodies, as parameters do not meet Indian standards for water quality.

From table 1, it is evident that Kamwari River in Tilak ghat area is slightly less polluted than that at Khadipar area. Tilak Ghat region is surrounded by encroachments of industries and residential complexes on river bank. Also work is in progress on the river area near Tilak Ghat bridge to systematically fill it for construction purpose. On the other hand at Khadipar region river is comparatively more affected due to saline water intrusion and more number of sizing, dyeing, weaving, power looms units, etc. Another observation of the water bodies sample suggests that Kalher, Bhadwad, Purna and Rahnal lakes are more polluted than Kopar, Narpoli and Diwanshah lakes, as per the amount of Turbidity, EC, TDS, Chlorides and Phosphate ranges are far beyond the permissible limit.

The fish catch was observed to be tremendously affected in all the water bodies in Bhiwandi probably due to high turbidity. Fishes are anticipated to undergo sub lethal stress from suspended sediments/turbidity. Such turbid waters harm fishes and other aquatic life by reducing food supplies, degrading spawning beds, and affecting gill function [20]. This might be one of the reasons for decrease of fish catch in Khabao, Tilak Ghat, Khoni, Katai areas on stretch of Kamwari River. Further, turbidity can reduce dissolved oxygen and alter the trophic structure, which can cause reduction in planktonic and periphytic food sources; increased stress levels which can reduce feeding, growth rates; increased energetic costs; and lower immune system response to viral and bacterial infections. It also reduces the quality of water bodies, affecting human health and recreation [17]. High levels of turbidity indicate increase in pathogens which leads to sloughing of biofilms. This restricts penetration of the sunlight and growth of nutrients, which affects the primary productivity. While conducting social survey during the study, we have come across cases of people living on the banks of this polluted river suffering from gastrointestinal disorders, jaundice, diarrhoea, cholera, etc. It was evident from the Public Health Centre data.

The observation of pH in water samples did not show major fluctuations and was almost within the limit, despite of release of untreated chemical effluents in lakes and Kamwari River.Some pH-buffers systems useful in textile pre-treatment, dyeing and finishing are HCl and sodium citrate (pH 1-5), Citric Acid and sodium Citrate (pH 2.5-5.6), Acetic Acid and Sodium Acetate(pH 3.7-5.6), K_2HPO_4 and KH_2PO_4 (pH 5.8-8.0), Na_2HPO_4 and NaH_2PO_4 (pH 6-7.5) and Borax and NaOH (pH 9.2-11) [8]. Probably, reaction between natural buffers and chemical buffers and effluents might be responsible in regulation of pH within normal ranges.

Rise in TDS as seen in almost all samples of water bodies in Bhiwandi. It is opined that scaling in water pipes leads to entry of metal particles and impurities into human body via drinking water. The TDS measurement is a better reflection of the total mineral content of the water rather than a water hardness measurement [36]. The presence of dissolved solids in water may affect its taste. The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/l; good, between 300 and 600 mg/l; fair, between 600 and 900 mg/l; poor, between 900 and 1200 mg/l; and unacceptable, greater than 1200 mg/l. Water with extremely low concentrations of TDS is unacceptable because of its flat, insipid taste. In areas where the TDS content of the water supply is very high, the local public health authorities must be consulted (WHO/SDE/WSH/03.04/16).

Conductivity and salinity have a strong correlation with regards to different group of organisms, as they adapt to the ionic concentrations of their respective environments and absorb or excrete salts as needed. Bhadwad Lake and Kamwari River at both sites (Tilak Ghat and Khadipar) show unnatural salinity levels, this may be due to percolation of creek water. Drinking of saline water leads to high salt intake and develops major risk for hyper blood pressure and cardiovascular disorders in humans. Rise or decline in the conductivity and salinity negatively affects the metabolic abilities of the aquatic biota [20].

High amount of fluoride is also observed in water samples. It has been reported in another study that acute toxicity can occur after ingesting one or more doses of fluoride over a short time period which then leads to poisoning [10]. To produce signs of acute fluoride intoxication, minimum oral doses of at least 1 mg of fluoride per kg of body weight were required (Janssen.,*et al*. 1988).

Kamwaririver banks are heavily infiltrated with textile and dying industries along with other industries and it is evident that chlorides are entering river water and polluting it. Point sources such as natural sources, sewage and industrial effluents, urban runoff containing saline intrusion are responsible for chlorine intrusion. Excessive chloride concentrations increase rates of corrosion of metals in the distribution system, depending on the alkalinity of the water. This leads to increased concentrations of metals in the supply. Chloride concentrations in excess of about 250 mg/litre can give rise to detectable taste in water, but the threshold depends upon the associated cations. Consumers can, however, become accustomed to concentrations in excess of 250 mg/litre [6]. According to Yan-feng LI, Jiu-sheng LI, Hang ZHANG, usage of water containing high chlorine levels in the soil results in increase in salinity. This also led to weak accumulation of nutrients factor in the top layer of soil. High concentration of chlorides is considered to be the indicators of pollution due to organic wastes of animal or industrial origin. Presence of chlorides in irrigation water is not ideal for growth of crops and soil and also detrimental to aquatic life [5].

Concentrations of bromide in fresh water typically range from trace amounts to about 0.5 mg/l. Negative human health outcomes, including cancer and reproductive and endocrine system problems are well documented for chlorinated and brominated compounds, including the halogenated organics that form in drinking water treatment [1]. Such polluted water, if used for irrigation in agriculture, will bioaccumulate in crops and gradually biomagnifies.

Narpoli Lake shows high levels of sulphates. Overall, Napoli Lake is less polluted in comparison with other water bodies. Water polluted with sulphates does not support crop growth and results in decreasing crop yield [31]. The presence of sulfate in drinking-water can also result in a noticeable taste; the lowest taste threshold concentration for sulfate is approximately 250 mg/litre as the sodium salt. Sulfate may also contribute to the corrosion of distribution systems. No health-based guideline value for sulfate in drinking water is proposed. However, due to change in noticeable taste of water as concentrations in water increase above 500 mg/litre, rise in complaints is observed too [31].

High concentrations of Phosphates in crops are adverse, it is primarily stored as phytate, which is indigestible, and which lowers absorption of other nutrients in non-ruminant animals, including humans [42]. The indigestibility of this form of phosphate means it ends up in sewage and water bodies [43]. All individual physico-chemical parameters play vital role in maintaining water potability, agricultural usage, riverine and lake ecosystem, etc.Any change in the normal values or absence of any parameter has direct ramification on environment and human health. Hence it is imperative to periodically check and maintain the water bodies for sustainability.

The peculiar conditions of physico-chemical parameters on river stretch is due to direct release of untreated sewage water, industrial effluents and solid waste disposal into it. The power looms, textile and dyeing industries established in the stretch of river bank by rampant encroachments, unchecked anthropogenic activities, and lack of maintenance and cleaning has led to conversion of river and other water bodies into a solid waste dumping yard. Low capacity Sewage Treatment Plants (STP), non- functional Effluents Treatment Plants (ETP) in textile units, power-looms without toilets and water theft for supplying to Textile Units are major issues in the area.Kamwari River samples from Tilak Ghat and Khadipar sites and samples of Diwan Shah Lake, Bhadwad Lake, Shelar Lake, Kalher Lake, Purna Lake, Khoni Lake, and Kopar Lake all exhibited declining rate of every physico-chemical parameter studied, which is clearly indicating to high level of pollution.

Conclusion and Recommendations

Careless disposal of wastewaters has severely polluted the river and has affected the quality of ground water too. For the protection and sustainable use of fresh water resources, maintaining healthy aquatic biota and human life, this study has provided existing status of physico-chemical parameters of water bodies of Bhiwandi region substantiating it with scientific data for the first time. Following measures have been outlined for revival and restoration planning.

For restoration and revival of water bodies and river it is essential to encourage local proactive groups and initiate task with identifying source of river and its total stretch up to confluence in sea. History and geography of the water bodies must be explored for proper data base, along with the number of people living on this stretch in villages and wards in city area, as it was done in the Kamvari river study. Identify and involve NGO's and local interested groups and offices for river rejuvenation work. On the stretch of river or from the areas close to water bodies, area wise groups must be formed for organizing 'river darshan' for students and society routinely. During the visit show source and emerging issues, for sensitizing and involving all stakeholders in process of revival of river and its biodiversity. Mainly this must be started for school students as their parents remain interested with them. 'Jal Sadhak' (Water Seeker) must be created with 'Jal Sanskar' (Water Sacrament). Volunteers must be trained and prepared for conducting periodic sampling of water bodies.

Secondly, as Novel COVID-19 pandemic lockdown has shown that rivers have self-restoration capacity and could automatically revive and flow smoothly if waste water or effluent release in river is stopped. Otherwise with millions of funds also river cleaning is not possible. Hence, at least intermittently in a year or six-monthly basis such lockdown must be practiced.

Third, river and sewer must be separated. Hence sewage treatment plants and effluent treatment plants with its full capacity must be installed and treated water must not be released in river or any water body. Such treated water must be recycled and reused for gardening, farming and other cleaning process. Bio sanitizers must be used for water cleaning.

A new integrated approach Working Model (Figure A) for creating social and administrative impact and mitigation measures is suggested here to appropriately design a restoration plan for river rejuvenation and revival of water bodies in Bhiwandi city. The same model may be replicated in other places for where there are issues of similar nature. This model insists concept of professionalization (officers, authorities and elected public representatives) and rationalization (citizens), insisting scientific study and division of tasks and careful allocation of resources which could increase work efficiency of all concerned. This shall also respond to social and administrative reforms. The range of concern attribute to become progressive and bring reforms aimed at giving citizens the information and power to understand and act on issues. The idea of Progressive mind is to remind society about particular duties to be fulfilled and they must be properly trained and equipped to fulfil same. This is a model in which citizens principle driven participation and membership in social organizations happen. They select their own favoured voluntary organizations on basis of principles, participate in their activities, receive communication and contribute in special tasks as an informed citizen. Therefore, extensive water literacy, encouraging women's participation and networking as Jal Saheli's do in Buldhana, MP State, good water governance, etc. is imperative. Rationalization is important for citizen behaviour and civic information. Under this framework citizens must perform and handle best manner to articulate social concerns. Jalnayaks and Jaldoots who are water warriors recognized by government of Maharashtra, continue to represent and exemplify the above practices and standards.

Below given is a New integrated approach model suggested for authorities to work with Forest, education, water resources, irrigation and land departments together and not in isolation.

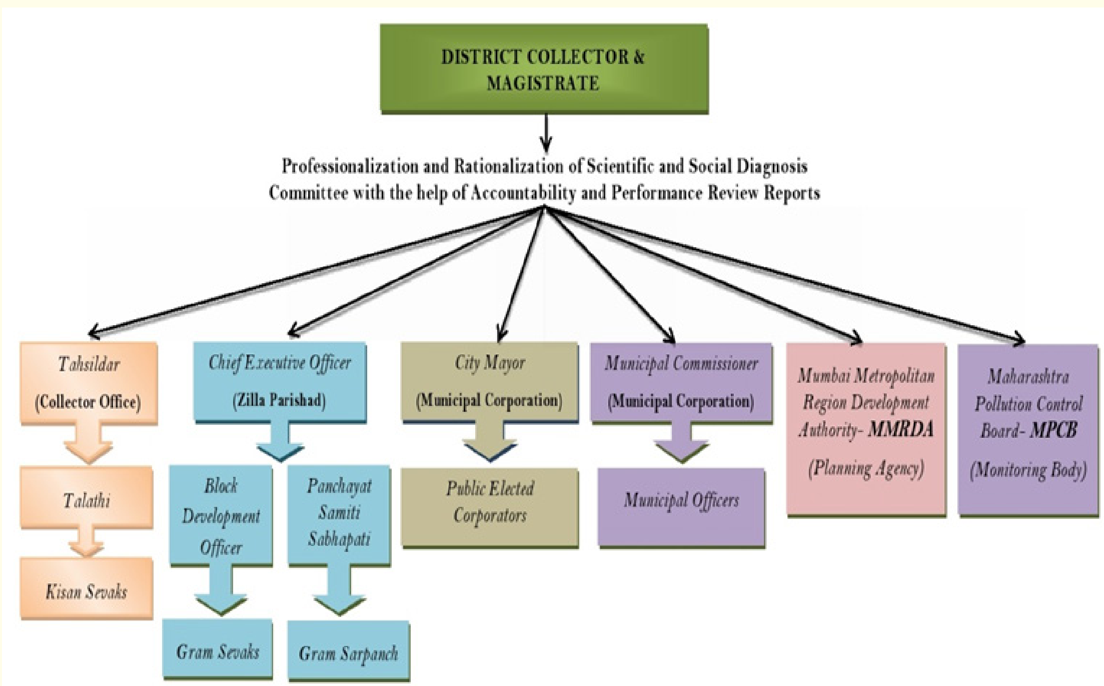

Figure A: A new integrated approach working model for impact and mitigation(For pollution control and development).

Keeping in view objectives and diagnosis of the study, following suggestions are given to outline the mitigation blueprint with other stakeholders of society towards sustainable lifestyle. Integration of Administrative authorities, academic institutions, NGOs, corporate sector and other citizens is equally important along with scientific solution, for waterbodies restoration. Following action must be taken for Kamvari river and other water bodies revival:

- Organize Water literacy program in schools and colleges
- Introduce river literacy in curriculum and project work for repository
- Organize *Prabhaatfherees* for creating awareness and mobilize public involvement in river restoration
- Create awareness about Rain Water Harvesting in Housing societies, hospitals, industries, etc for ground water recharge
- Ensure effective implementation of Rain water harvesting (RWH) policy of government.
- Install sign boards on bank of river and water bodies making people aware of importance of water and penalty for misuse
- Restore agriculture as occupation by controlling pollution in Kamwari river
- Training and meetings with KisanSewaks, Gram Sewaks, Gram Sarpanch, Gram Sadasya and Gram Panchayat Samiti members regarding water conservation, water literacy and prevention of water body pollution measures
- Authorities must ensure proper STPs (capacity) and ETPs installation and monitor its functioning
- Proper disposal of post-treatment sludge and treated effluent or sewage water. Restrict its release in the river or sea
- Implement remote sensing, GIS and satellite mapping for monitoring encroachments
- Conduct systematic study of ground water levels with help of geologists
- Periodic monitoring of water bodies by MPCB is obligatory to keep check on polluters.

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Bibliography

1. Bromide in drinking-water Background document for development of WHO Guidelines for Drinking-water Quality, World Health Organization, WHO/HSE/WSH/09.01/6.
2. Bureau of Indian Standard, Indian Standard Drinking Water - Specification (Second Revision), IS 10500 (2012).
3. Can You Determine Water Hardness From Conductivity Or Total Dissolved Solids Measurements? Global Water A Xylem brand.
4. Census of India. Maharashtra Series 28 Part XII-A, District Census Handbook Thane, Directorate of Census Operations (2011).
5. Chloride in drinking-water Background document for development of WHO Guidelines for Drinking-water Quality, World Health Organization, WHO/SDE/WSH/03.04/03.
6. Chloride in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality (WHO/SDE/WSH/03.04/03).
7. Controlling Pollution in Textile Industry, posted on November 12, 2016 by OEM Update Editorial.
8. Dying and Dying Process, pH and pH buffers (2012).
9. Fluoride in drinking-water Background document for development of WHO Guidelines for Drinking-water Quality, World Health Organization, WHO/SDE/WSH/03.04/96.
10. Fluoride in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality (WHO/SDE/WSH/03.04/96).
11. Giller S and B Malmqvist. "The Biology of Streams and Rivers". Oxford University Press, Oxford (1998): 296.
12. Guignard MS., *et al*. "Impacts of Nitrogen and Phosphorus: From Genomes to Natural Ecosystems and Agriculture". *Frontiers in Ecology and Evolution* 5(2017): 70.
13. History of Bhiwandi.
14. Hynes HBN. "Ecology of Running Waters". Originally published in Toronto by University of Toronto Press (1970) 555.
15. Indian Meteorological Department, Regional Meteorological Centre.
16. Jeanne M Van Briesen. "Potential Drinking Water Effects of Bromide Discharges from Coal-Fired Electric Power Plant".

17. Arivoli Appavu., *et al*. "Study of Water Quality Parameters of Cauvery River Water In Erode Region". *Journal of Global Biosciences* 5.9 (2016): 4556-4567.

18. Journal of Integrative Agriculture 13.9: 2049-2060

19. Kanduti D., *et al*. "Fluoride: a review of use and effects on health". *Materia Socio-Medica* 28.2(2016): 133–137.

20. Kjelland ME., *et al*. "A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications". *Environment Systems and Decisions* 35(2015): 334.

21. MMRDA Bhiwandi Surrounding Notified Area (BSNA).

22. Mino Yoshiki and Mayumi Yukita. "Detection of High Levels of Bromine in Vegetables Using X-Ray Fluorescence Spectrometry". *Journal of Health Science* (2005).

23. Moreno-Casas., *et al*. "Environmental impact and toxicology of sulphate" (2009).

24. National Geographic, Freshwater Crisis.

25. Nitrate and nitrite in drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality, World Health Organization, WHO/SDE/WSH/07.01/16/Rev/1.

26. Nitrate in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality (WHO/SDE/WSH/07.01/16/Rev/1).

27. Noss RF. "Indicators for Monitoring Biodiversity: A Hierarchical Approach". *Conservation Biology* 4.4(1999): 355–364.

28. Paula Abrams. Water in Religion.

29. pH in drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality, World Health Organization, WHO/SDE/WSH/07.01/1.

30. Resource Library. Encyclopedic Entry Civilization.

31. Sulphates in drinking-water Background document for development of WHO Guidelines for Drinking-water Quality, World Health Organization, WHO/SDE/WSH/03.04/114.

32. Total Dissolved Solids in drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality, World Health Organization, WHO/SDE/WSH/03.04/16

33. Total dissolved solids in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality, WHO/SDE/WSH/03.04/16.

34. Thane District Collector and Magistrate.

35. Thane Zilla Parishad.

36. Turbidity – A General Overview. Water Quality/Impaired Waters #3.21 (2008).

37. Verma SVS and McNab JM. "Chemical, biochemical and microbiological examination of guar meal". *Indian Journal of Poultry Science* 19.4 (1984): 165-170.

38. Vinson MR and CP Hawkins. "Biodiversity of stream insects: variation at local, basin, and regional scales". *Annual Review of Entomology* 43 (1998): 271-293.

39. Water Quality and Health - Review of Turbidity, Information for regulators and water suppliers, WHO/FWC/WSH/17.01.

40. Hindustan Times, Mithi River an open drain, another 2005-like deluge inevitable in Mumbai: Panel report to SC, Badri Chatterjee (2018).

41. Chan Ngai Weng. "Sustainable management of rivers in Malaysia: Involving all stakeholders". *International Journal of River Basin Management* 3 (2005): 147-162.

42. Veneklaas EJ., *et al*. "Opportunities for improving phosphorus-use efficiency in crop plants". *New Phytologist* 195 (2012): 306-320.

43. Guignard MS., *et al*. "Impacts of nitrogen and phosphorus: From genomes to natural ecosystems and agriculture". *Frontiers in Ecology and Evolution* 5 (2017).