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Nano Technology in Water Treatment: A Case Study of Mysore City

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Abstract

Water is one of the essential companions of life on earth. During the phases of creation, evolution and continuity of life on earth, water remained as its most vital component. Clean and fresh water is essential for the existence of life. Potential water scarcity is being recognized as a threat to human activity. Water resources continue to diminish due to overuse, waste, and pollution. The current water treatment capacities for securing clean water will be unable to meet the needs of the growing population. Clean drinking water is becoming an increasingly limited resource in many parts of the world and as consequence water purification technologies are gaining major attention worldwide. Sustainable development of water treatment technologies requires innovative techniques to provide safe drinking water in a cost and energy efficient manner. Against this background, the adaptation of highly advanced, Nanotechnology in particular, offers the potential of long-term solutions to increase energy efficiency and lower costs, through the adaptation of advanced filtration materials that enable greater water quality and reuse. The present study aims to understand the filtration capacity of the units that are located in the study area, to study the nanotechnology used in filtration of drinking water, and how nanotechnology impact on environment in the study area. The present study is based on both Primary and secondary source data. The study was conducted in Mysore city; primary data have been collected from field survey and personal observation. Data is analyzed through simple quantitative techniques like Pearson's correlation coefficient. The result show that the role of nanotechnology in water treatment is overestimated; while advantages are not more than theoretical assumptions, while the disadvantages are almost certain. Waste waters stay toxic after treatment by nano materials.

Keywords: Nano Technology; Pearson's Correlation; Filtration

1 Introduction

A small and inadequate amount of water is a critical threat to the current and future wellbeing of people. In particular to developing countries, sustainable water management is a vital side of solving the problems of poverty. Safe drinking water is very important to the protection of human wellbeing. Water related diseases are the most common cause of skin disease, sickness, death among the poor in the developing areas. According to World Health Organization about 6% of the worldwide disease is related to infection from water; diarrhea being the most. More than 4500 children under five year of age die every day from disease such as diarrhea. Access to safe water close to home will save amount of the time that can be used for developing productive activities which is the basis of economic growth. Lack of access to water reduces the amount of food available in both crops and livestocks and the quality.

Nanotechnology could play an essential role in solving this water crisis by introducing effective and cheap wastewater treatment techniques. The main aim of this paper is to assess the applicability of using Nanotechnology in water treatment in Mysore. In order to achieve this aim, the paper discusses the definition of Nanotechnology and the green Nanotechnology applications areas. Also, this paper illustrates the potential impacts and risks of Nanotechnology. Then we illustrate the case study of Mysore city in using Nanotechnology to solve the problem of water scarcity. The study concluded that although Nanotechnology can help solve the water problems. There are some challenges that hinder using Nanotechnology. These challenges include technology, financial, market challenges and human health risk.

2 Database and Methodology

The Present study is based on both primary and secondary source data. Since the area of study is limited to Mysore city, the study highlights how the technology positively and negatively impacts on the water and environment of the city. The secondary data collected from various reports, article and books. The primary sources of data have been collected from field survey through questionnaire and observation. Data is analyzed though simple quantitative techniques like Pearson's correlation co-efficient between physio-chemical parameters, to achieve the goal of studies.

2.1 Study Area

Mysore City is an Ancient, historic and one of the beautiful cities of the country. It is the 2nd largest city in the state of Karnataka, next to Bangalore. It lies about 146km (91 miles) southwest of Bangalore, the capital of Karnataka. The Mysore city is located between 12° 14' 41"N to 12° 22'25" N latitudes and 76° 34'20"E to 76° 43'23"E longitude at an altitude of 2526ft above the mean sea level (Map.1). Mysore city Spread across an area of 128.42 km2 (50 sq.miles) & it is lies in the saucer shaped basin & is situated at the base of the Chamundi hills. The City of Mysore in Karnataka is one of the most visited tourist destinations of the state. City is divided into 9 Zones, and they sub divided as 65 wards by MCC (Mysore City Corporation) based on 2011 data. The population is about 8, 93,062 in 2011 census, with males 4,46,676 and 4,46,386 females respectively.

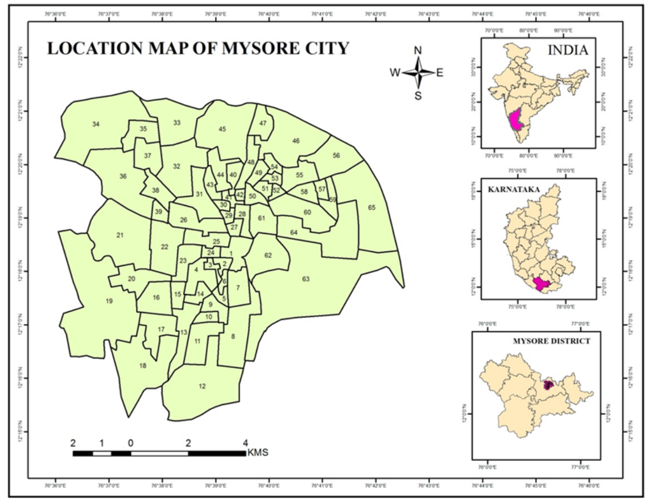

Fig. 1. Location of Mysore City with Wards

Based on the Information's from the Vani Vilas Water works (VVWW), Mysore. There are four treatment plants in Mysore, the ownership belongs to Mysore Urban Development Authority (MUDA). The treatment plant in Belagola scheme is the oldest water supply to the Mysore city and commissioned in the year 1896. In Belagola the head work is located at a distance 9 Kms away from city. The water is drawn from Devarayana canal near Belagola village. Out of two treatment plants in Belagola scheme the filter bed of old water treatment plants are dilapidated condition and are not in operation. Hence, the overall treatment process from this plant is based on the second stage of treatment plant. In Belagola the filter back water discharging Kukkurahalli Lake. The treatment plants in Hongally-II and Hongally-III the water drawn from low level canals of Cauvery by gravity pressure. The Hongally head work is located at a distance of about 14 Kms away from city.

3 Results and Discussions

3.1 Importance of Nano Technology

Water shortages and lack of access to safe drinking water will continue to grow as major global problems. More than one billion people lack access to safe drinking water and 2.4 billion people lack access to proper sanitation, nearly all of them in the developing countries. Around third of the world's population live in water-stressed countries, and by 2025, this is expected to rise to two-thirds. One of the approaches being explored in many countries, including South Africa, to tackle this challenge of increasing access to clean drinking water, is the application of nanotechnology. Nanotechnology could play an essential role in solving this water crisis by introducing effective and cheap wastewater treatment techniques.

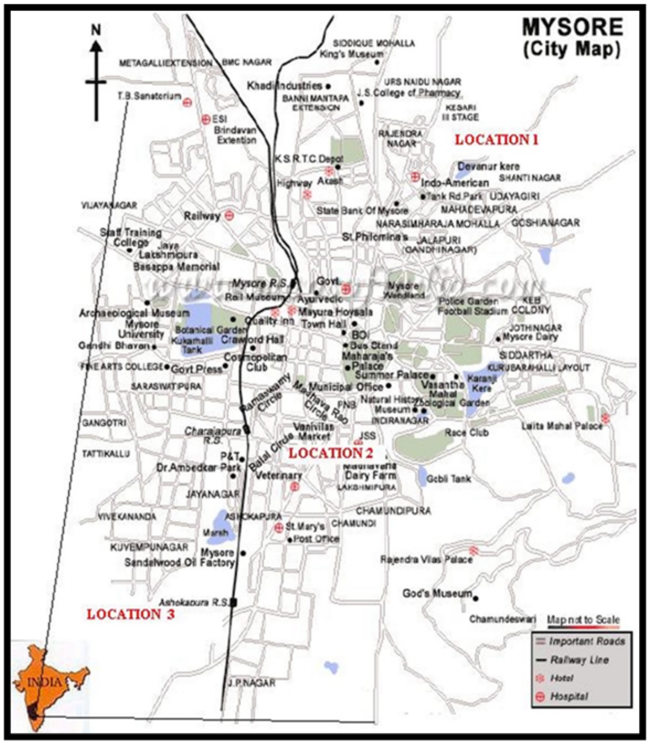

Fig. 2. Location of Water Treatment Plants

3.2 Applications

1. **Small scale purification:** Nanotechnology enabled water treatment process utilizing metal nanoparticles, nanostructured photo catalysts membrane and Nano adsorbents can elucidate and fix most of the water quality problems.
2. **Metal nanoparticles**: Metals and oxides of metals such as silver, oxides of titanium and zinc are capable of disinfection because of antimicrobial activity due to their charge capacity.
3. **Magnetic nanoparticles**: Magnetic nanoparticle with a size of 20nm has relatively high potential to remove toxic and carcinogenic chromium from water, with removal capacity of around 2μgCr/mg in water. This is successfully applicable for small scale system because of its lower cost for the preparation of magnetic nanoparticles.
4. **Nano adsorbents:** Various organic chemicals have been adsorbed more efficiently by carbon nanotubes (CNTs) than activated carbon. However, polymeric nanomaterial like dendrimers, are also able to remove both organic chemicals and heavy metals from water.
5. **Nano membrane:** Generally, membrane treatment process is either pressure driven or electrical driven. Pressure driven treatment technologies include reverse osmosis, Nano filtration and ultrafiltration.

There are four treatment plants in Mysore, the ownership belongs to Mysore Urban Development Authority (MUDA). The capacities of each plant were mentioned in Table 1.

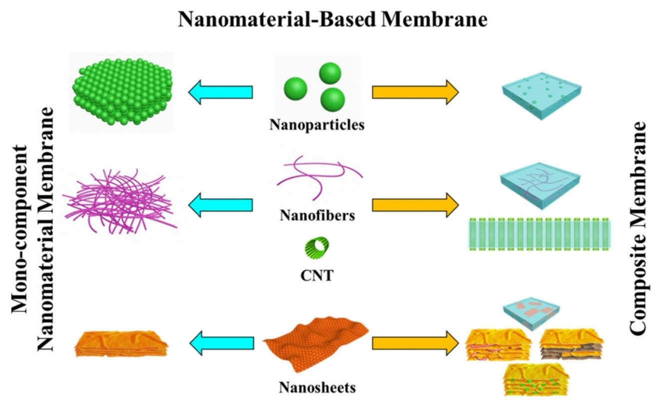

Fig. 3. Nanomaterial-based membrane

Treatment Processes Assessment The raw water is treated in all four Water Treatment Plants (WTP's) by a conventional water treatment method which comprises coagulation/flocculation, sedimentation, filtration followed by disinfection (Table 2).

The waste management was not taken seriously and the plants in Hongally the backwash water and the sludge from the clarifier and sedimentation tanks directly discharging into the drain. The water treatment plant in Melapura was the 4th stage of water supply scheme to Mysore city. From head works near Melapura village raw water is directly pumped to existing water treatment plants located at Ramanahalli village through vertical turbine pumps. The pipeline from head works to WTP is 1100 mm diameter MS pipe and covers a distance of about 6.5 Kms. The head work of Melapura is located at a distance of about 15 Kms from city. In Melapura plant the filter back wash water and sludge from the clari-floculator goes to Ramnahally Lake. For all four treatment plants alum is used as the coagulants. Out of four water treatment plants two plants (Belagola and Melapura) having aeration facility. The most common type of filter for all four water treatment plants is rapid sand filters. In terms of disinfectants, four plants using liquid chlorine. The details of treatment process is mentioned in Table 2.

3.3 Physio - Chemical Water Quality

The seasonal variations of physio-chemical parameters of raw water and treated water samples from all four plants are shown in Tables 3 and 4 respectively.

Table 1. Key Details of WaterTreatment Plants (WTP's) in Mysore

SL No	Name of the Plant	Location of Pump House	Design Capacity in MLD	Present capacity in MLD	Year of Construction	Method of Treatment	Area of Supply
1	Belagola water supply scheme	Belagola				Sedimentation	Vanivilas Reservoir
	(I stage)		16	13	1896	+ Filtration	
	(II stage)		36	27	1998	+ Disinfection	
2	Hongally water supply scheme	Hongally				Sedimentation	Yadavagiri Reservoir
	Hongally- II		36	32	1956	+ Filtration +Disinfection	
3	Hongally -III	Hongally	55	55	1979	Sedimentation +Filtration +Disinfection	Kuvempunagar Reservoirs
4	Melapura water supply scheme	Melapura				Sedimentation	Devnoor & German Press Reservoirs
	(I- Stage)		50	30	2002	+Filtration	
	(II -Stage)		50	30	2007	+Disinfection	

Sources: Vani Vilas Water works (VVWW), Mysore

Table 2. Treatment process of each plant

Name of the Plant	Type of Areator		Type of coagulant	Sedimentation type		Filtration system			Disinfection	Laboratory equipment	
	Yes	No	Solid type	OSH	CSRE	SSF	RSF	PF		Yes	No
Belagola	Cascad Type		Alum	✓			✓		Liquid Chlorine	✓	
Hongally-II		Channel feed	Alum	✓			✓		Liquid Chlorine		✓
Hongally-III		Channel feed	Alum	✓			✓		Liquid Chlorine		✓
Melapura	Cascad Type		Alum	✓			✓				✓

3.4 Statistical Analysis

For the correlation study we used few physio-chemical parameters to check the inter-relationship of each parameter. Statistically, using Pearson's correlation coefficient pH was found to be positively and significantly related to Residual chorine. Turbidity was found to be significantly and positively related to Residual chlorine. EC was found to be significantly and positively related to DO, TDS and TH. The dissolved oxygen was negatively related to TDS and TH. Total dissolved solids were found to be positively related to Total hardness. Rest of combinations was not significantly related to each other (Table 5).

3.5 Administrative Issues

In Mysore the water treatment plants are run by the operators of concern plant under the supervision of in-charges and executive engineers. The most of the operators are having lack of technical knowledge regarding determining the flow rates, chlorine dosage and minor repair of the equipment. However, the in-charges of the concern plants are fairly knowledgeable about the proper functioning of the plants. The major issues of the plants are the lack of communication between the executive engineers and the operators. This may be due to the difference in educational qualifications. Most of the plant operators are not qualified to handle the technical operations. The plant operators are not aware about the international water quality standards.

Table 3. Seasonal Variations of the Physio-Chemical Parameters of Raw Water Samples Collected From WTP's in Mysore

Sample Location	pH	Temperature (*c)	Turbidity (NTU)	Conductivity (us/cm)	Dissolved oxygen	TDS (mg/L)	TH (mg/l as $CaCo_3$)
Raw Water							
Winter- December 2022 – February 2023							
Belagola	8	21.6	4.1	306.6	7.5	146.6	114.6
Melapura	8.1	22	4.3	304	7.4	145.3	115.3
Hongally-II	8	21	5.4	288.6	7.2	146.6	121.6
Hongally-III	8	21.3	5.2	288.6	7.2	146.6	121.6
Mean	8	21.4	4.75	296.9	7.3	146.2	118.2
Summer – March 2023 – May 2023							
Belagola	8.2	27.3	5.6	342	7.3	166.6	51.3
Melapura	8.2	27	3.2	350	7.2	180	51.3
Hongally-II	8.2	27.3	4.4	331.3	7	163.3	44.6
Hongally-III	8.2	27.3	4.4	331.3	7	163.3	44.6
Mean	8.2	27.2	4.4	338.6	7.1	163.3	47.9
Monsoon – June 2023 – August 2023							
Belagola	7.7	24	6.5	119.3	7.7	81.3	128.6
Melapura	7.7	24.6	4.6	120	7.8	89.3	120
Hongally-II	7.6	24	6.5	84.7	7.7	62	106
Hongally-III	7.6	24	6	84.6	7.7	62	106.6
Mean	7.6	24.1	5.9	102.1	7.7	73.6	115.4
Sources: Vani Vilas Water works (VVWW), Mysore							

Table 4. Seasonal Variations of the Physio-Chemical Parameters Treated Water Samples Collected From WTP's in Mysore

Sample Location	pH	Temperature (*c)	Turbidity (NTU)	Conductivity (us/cm)	Dissolved oxygen	TDS (mg/L)	TH (mg/l as $CaCo_3$)	Residual Chlorine
Raw Water								
Winter- December 2022 – February 2023								
Belagola	7.8	21.3	1	304.6	7.3	144	116.6	0.8
Melapura	7.8	21.3	0.6	302	7.4	145.3	116.6	0.6
Hongally-II	7.8	20.6	0.8	286.6	7.2	145.3	121.3	0.8
Hongally-III	7.9	21	1	286	7.2	145.3	121.3	0.9
Mean	7.8	21.05	0.85	294.8	7.2	144.9	118.8	0.7
Summer – March 2023 – May 2023								
Belagola	8	26.6	0.8	340	7.3	166	53.3	0.7
Melapura	8	27	0.7	347.3	7.1	178.6	52.6	0.5
Hongally-II	7.9	26.3	0.9	329.3	7.1	162	45.3	0.7
Hongally-III	7.9	27	0.9	328	7.1	162	45.3	0.7
Mean	7.9	26.7	0.8	336.1	7.1	167.1	49.1	0.6
Monsoon – June 2023 – August 2023								
Belagola	7.6	23.3	1.3	116.6	7.6	82.6	123	0.9
Melapura	7.5	24	0.8	118	7.7	90.6	121.3	0.7
Hongally-II	7.4	23.3	1	84.6	7.7	64	105.3	0.6
Hongally-III	7.5	23.6	0.8	82	7.7	64	105.3	0.6
Mean	7.5	23.5	0.9	100.3	7.6	75.3	113.7	0.7
***Monthly average values of each seasons are presented**								
Sources: Vani Vilas Water works (VVWW), Mysore								

Table 5. Pearson's Correlation Co-Efficient Between Physio-Chemical Parameters

	pH	Temp	Turbidity	EC	DO	TDS	TH	RC
pH	1							
Temp	.300	1						
Turbidity	.286	-.309	1					
EC	.082	.230	-.151	1				
DO	-.130	-.237	.098	.904**	1			
TDS	.164	.295	-.144	.971**	-.894**	1		
TH	.118	.040	-.102	.943**	-.842**	.935**	1	
RC	.341*	-.263	.963**	-.072	.048	-.052	.000	1

*Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

The training of the operators according to the international standards will be useful for the proper running of the plant. Among four water treatment plants only two plants (Melapura & Vanivilas) having the laboratory facility attached to the plant. The treatment plant Melapura having automated facility. The issue noticed during the survey study was the electricity usage. In many plants they are not operating the clari-floculator units properly. Another observed issue is about the poor maintenance of the plants. In some plants noticed the prolonged equipment errors, but the finished water quality they will be maintained based on the excess chlorine dosage. The in-charges of concern plants are very much bothered about the finished water quality. This will be resulted for over dosage of chlorine in some seasons.

4 Conclusion

Nanotechnology for water drinking water treatment is gaining momentum through a global perspective. The unique properties of nano materials and their emergence with current water treatment technologies present great opportunities to revolutionize water treatment. Although many nanotechnology strategies highlighted in this review are still in the laboratory stage, some have made their way to pilot testing or even large-scale commercialization. However, there are still potential drawbacks. Major practical challenges are the cost of nano structured materials along with the difficulty in scaling up Nano based treatment processes for commercial use. In addition, health and safety issues around the use of nano materials have to be addressed in the domestic water industry, particularly with respect to the direct application of nanoparticles into the receiving natural bodies of water. Materials functionalized with nanoparticles incorporated or deposited on their surface have risk potential, since nano particles might leach into the environment where they can accumulate for long periods of time. As a result, nano materials can be embedded into various platforms (e.g., nano composites as discussed in this chapter) to avoid leaching into the system. However, current immobilization techniques require further optimizations to mitigate the loss in efficiency. Additionally, the longevity of these nanotechnologies is largely unknown as most lab studies were conducted for relatively short intervals. If integration of nanotechnologies is a future goal, then studies that address the long-term performance of water and wastewater treatment.

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