Global Journal of Enterprise Information System

Drinking Water Supply and Sanitation: A Typical Syndrome in Sub-Urban Rural Areas: Require Scientific and Technological Intervention

Anand Verdhen[1*]

[1*]*Professor, Department of Civil Engineering, Dronacharya College of Engineering, Khentawas, Gurgaon, India; a_vardhan1022006@rediffmail.com; averdhen4@gmail.com*

Abstract

The population and industrial growths are demanding for sustainable and safe drinking water and waste disposal in rural and urban belts. Deficiency and lack of fresh water supply and sewage disposal/treatment affects the health and hygiene of household, community dwellers and local/regional environment. The paper highlights the problems around Farukh Nagar of Gurgaon District in Haryana and suggests for scientific and technological study to address the issue. Preliminary field visit and study show the gravity of problem and possible reasons. However, detailed study is required adopting scientific and technological viable strategy including methodology, questionnaire based interaction with beneficiaries and agencies to collect stratified socio-economic and technical primary and secondary details/records, people perceptions and experiences, Ground water details (level, yield, point source and quality fluctuations), Surface water source, rainfall, water supply system/parameters, population and growth, waste water and sludge production, treatment and disposal system, recharge and outfall zone in the study/nearby areas, etc. Further, analysis of data employing hydrological/hydraulic software, testing/verification of quality parameters with Indian and international standards, physical models, workshops among beneficiaries and user agencies addressing the points of innovation to implement viable and sustainable water supply and sewage disposal plans are needed.

Keywords: Drinkable Water Supply, Waste Water Disposal, Ground Water, Quality, Environment, Innovation

1. Introduction

The availability of surface and ground water resources are becoming uncertain in Haryana as in India. The water resources of India are unevenly distributed over space and time. The western India experiences extreme dry climate whereas eastern India (Cherrapunji in Meghalaya) is the wettest place of the Earth. Some rivers have perennial and/or seasonal flow with huge discharge to the sea. Ground water table/peziometric head is varying and depleting with space and time. Subsequently, fresh and safe drinkable water is a major problem in most of the places of India. The National Water Policy has given priorities to drinkable water for making available to all without any discretion. Rajeev Gandhi National Drinking water mission is in operation since last 30 years. But, masses are far away from the access of safe drinkable water due to growth in population, over exploitation of ground water, recharge deficiency; poor and polluted water, wastage of water and half hearted planning. There is rapid development in urban area but water distribution system is traditional which requires automation. Another major problem is connection of suction pumps to suck the water directly from the main supply line.

Similarly, in the Vedic era, Bharat was well planned and very much near to the nature by maintaining high level of purity and worshiping each and every resource. The resources were used with a sense of conservation and sustainability without over-exploitation or damage or pollution to the resources. Indian practices and vision of Rastrapita Mahatma Gandhi on waste disposal practices were beneficial and congenial, but the recent development, urbanization, loss in sense of environmental and social responsibilities made the sewage production, disposal/treatment a gigantic and challenging task. Problem has been multiplied and aggravated further by centralizing the sewage collection and disposal system without assessing the negative impacts. A planned approach of Shri Bindeswari Pathak for the sanitation services, known as Sulabh Sauchalaya was a breakthrough, but who will like to pay a silly amount frequently for this service online to search change before chain. Governments and voluntary organizations are doing their best/worst to solve these increasing problems through

*Author for correspondence

various projects, departments and municipalities to keep the environment clean and green. The total waste water generated by about 300 class-1 cities is almost 81% of the water supplied or used. The level of treatment available in these cities with existing treatment plants varies from 2.5 % to 89% of the sewage generated[2]. Aarshi[1] summarizes that most of the people living in Delhi are unaware of the fact that they are party to pollute the River Yamuna. Eco-sanitation and waterless sanitation systems are in use but sustainability, soci-economic, user satisfaction and effectiveness are not viable.

At an international level the situation is also not very good from sewage and waste water treatment and disposal points of view. The residential, commercial and industrial development in Hudson Valley has resulted in increased quantities of solid waste and sludge which require treatment and disposal. Presently, disposal is into water bodies or in landfills. New-York States are forcing municipalities to plan for waste management in the regions (Dutchess, Orange, Putnam, Rockland, Sullivan, Ulster and Westchester) providing partial funds and asked the New York State Environmental Facilities Corporation to investigate alternatives for managing their sludge. After in-depth analyses the investigating corporation suggested five management alternatives as i) to develop a regional sludge and septage management system and ii) a permanent management taskforce under the coordination of Hudson Valley Regional Council including three alternative technologies: iii-v) incineration, land application and landfill. UNICEF's broad view of sanitation reflects perceptions of pollution and cleanliness in environment and to stimulate household toilets. Interestingly, there are examples of successful effort by the government agencies, voluntary organisations and individuals in India and abroad. Nepal Water and Health (NEWAH) organisation has grown rapidly since 1992 to 1997 in South-Asia and initiated 50 time bound (18 months) new projects each year and completed a number of subsidized (50%) toilet options. Similarly, the Mvula Trust was established in 1993 to improve the health and welfare of rural and sub-urban South-Africans through increasing access to safe domestic water and sanitation services. Sanitation is subsidized by the Government and a minimum contribution of 8% of the capital cost is expected for a toilet from household. Another example concerning headquarters of Berberati, Bouar and Bossangoa and surrounding villages are about the improvement in living conditions through rehabilitation, water supply and sanitation systems[11]. The technical choices were construction of separate Manual Flush Toilets (MFT) for ladies and gentlemen and Ventilated Improved Pits (VIP) for sewage disposal. For the treatment of solid wastes landfill, incineration and composting options were examined and option of the controlled landfill was adopted which includes fencing, wastes spreading and compaction to avoid dispersal. Overall, assessment reveals a sanitation service (from the current 10% to 20% in 2020) in the project area. Interestingly, situations of water demand and sewage productions in cold climatic regions are not as high as in India. Thus in European countries innovations are not required for sewage disposal/management as required in India having limited resources and diverse situations.

Overall there is wide deficiency in fresh water availability and supply for the household in the country. Neither rural/municipal water supply agencies nor the users are satisfied with the traditional and adhoc system. On the other hand, the price of bottled water (uncertain quality) is higher than the cost of fruit juice/cold drinks. Research is needed to improve and make the system technologically viable and sustainable. There is gap in national and international levels[3] to give area specific solution. WMO has published guidelines (Edition I, II and III in 1984, 1999 and 2008) for Drinking Water Quality. The guidelines are intended to support the development and implementation of risk management strategies that will ensure the safety of drinking water supplies through control of hazardous constituents. It is the preamble of WHO[12] that the access of safe drinking water is important for the health and development at local, regional and national level. Similarly, there is wide deficiency of mechanism and network for sewage and sludge collection, transportation, treatment and disposal produced from the urban/rural households and community. Neither rural/municipal agency nor the people are satisfied with the traditional and adhoc ongoing systems. Research is needed to improve and make the system technologically viable and sustainable. There is gap at national and international levels[3] to give area specific solution. The national and international guidelines are available for measuring the status and quality of health and sanitation. But it is important to develop and implement the strategy based on local socio-economic and technologically viable conditions for the health and sanitation at local, regional and national level. Planning, reliability, efficiency and quality related issues are important to be addressed effectively. Variables/ parameters/feedback supplied at the consumer's end would be important for performance evaluation using bench making techniques[5,6,10]. Consequently, through scientific and technological intervention area specific problems are needed to be addressed and resolved. The sewage treatment and disposal strategy, atomization and management can be improved technologically through a sound research plan and proposal.

An interested group of 2nd and 3rd year's students shall be identified and engaged in the project for field assessment and then shall be involved actively to improve efficiency of water conservation, drinkable water supply, sewage and sludge disposal plan and to develop model for an efficient management system.

2. Conventional Methodology

The volume of liquid sludge produced at a sewage treatment plants usually represents approximately 1-2% of the total flow of sewage, but treatment and disposal costs nearly 30-50% of the works. Sludge from conventional sewage treatment plants are derived from primary, secondary and tertiary processes. The primary sludge consisting largely of faecal solids contain paper, sanitary and medical products, kitchen wastes, grit and other mineral matter for which inlet screening, grit removal trap, etc. are used to remove non-biodegradable material and water can be used whenever possible. Humus sludge is the product of settlement of effluent from biological filters, submerged aerated filters, etc. and is mainly bacterial and fungal material are removed. In an activated sludge plant, polluting matter is mixed suspended solids and a portion of sludge, known as surplus activated sludge consisting of flocculated/synthesized solids and micro-organisms is removed at regular intervals. The fraction of secondary sludge that remains in the effluent from the secondary clarifier is removed by the tertiary treatment filters. Tertiary sludge rarely contains more than 1.0% dry solids. Conventional biological treatment of wastewater under aerobic conditions includes Activated Sludge Process (ASP) and Trickling Filter. The quantity of the return sludge measured after 30 minutes of settling is defined by the Sludge Volume Index (SVI) and expressed as sludge volume in mL for one gram of dry weight of Suspended Solids (SS). The SVI varies from 50 to 150 mL/g of SS. Lower SVI indicates better settling. The sludge which does not settle in sedimentation tank is called as bulking sludge. The sludge bulking can be controlled by air supply, eliminating shock loading to the reactor, or by increasing temperature of the wastewater or by small hypochlorite dosing to the return sludge line to avoid the growth of filamentous hygroscopic micro-organisms. Temperature maintenance is important for the sludge digestion. Anaerobic digestion has been broadly recognized as the core of sustainable waste management[4]. The UASB reactor is the most widely and successfully used high rate anaerobic system for sewage treatment[7]. The performance of the one-stage UASB systems at low temperature climates (5-20°C) is highly limited. The produced biogas may be reused for heating the digester content. The sludge recirculation improves both the physical removal of solids and the conversion, as it increases the methanogenesis from 20% in the one stage UASB reactor to 47 % in the two stages UASB-Digester system[8].

3. Study/Project Area

The project is envisaged to select a suitable populated zone and evaluate the adequacy, safety and sustainability of drinkable water supply, sewage collection and disposal system to evolve methodology for improvised and sustainably managed system.

The sample study for the status and water supply issues have been evaluated based on a field visits in Farrukh Nagar and villages around, i.e. Saidpur, Khentawas, Patli-Hazipur. The ground water of Khentawas and Farrukh Nagar and area around nearly 1-2 km^2 are saline which is increasing over years. In the past salt was prepared in Farrukh Nagar and transported through the exclusive railway for the same. Water supply pumps and systems are available but certainty of getting drinkable water is at stake even after adopting various measures i.e. increasing the depth of tube well or installing new tube wells in remote or supplying the water in shifting. A reconnaissance survey conducted reveals that people of urban or rural belts are spending sleepless night to wait for uncertain water supply and keep the pumps running for hours to withdraw water from main supply pipeline with hope to collect sometime fresh and usually saline water. Farrukh Nagar has series of shops to rewind the burnt motor of water pumps. Even the water supplying in-charge/personnel of PHED are not satisfied with such tragic situation but they are helpless. Picture 1 shows brief glimpses of situation at Khentawas which are deteriorating since last 3 decades. Khentawas contains nearly 300 cattle and 1500 population in 300 households. Old pumps of

Figure 1. Dry/defunct water supply well cum tube-well since last three decades.

Figure 2. Dry tube-well functional in monsoon with saline water supply.

Figure 3. Water tanker to provide untreated fresh drinkable water to needy.

Figure 4. Village Anganwari women (young to old) are highlighting water related problems.

Village Khentawas deliver saline water, not fit for drinking and at a distance of two kilometers fresh water is available but depth gone down from 50 m to 60 meter. One new submersible pump of similar 7.5 HP capacity has been installed 3 years back to augment the sump (storage tank).

A booster water pump plant of PHED is functional to supply the fresh/saline mixed water. Consequently, most of the villagers are managing to collect fresh water (salinity free ground water) for drinking from privately installed tube-well at one Km from village. Problem is so severe that some time people quarrel for getting water. Although Saidpur villagers have similar set of twin pumps for one-line water supply system of saline-free water but dwellers having road or their house plinth at relatively higher levels or at tail end are not able to find water in main pipeline and deprived from getting water to pump. Villagers have hope of treated water supply through canal to the booster pump as per recent costly plan which invites further investigation for its effectiveness. Apart from poor quality of water major issues are about pumping water directly from main supply-line.

Similar study conducted locally for the status of waste water, sludge and sewage treatment/disposal reveals that people of

Figure 5. Sump of 50,000 ltrs with Booster pump of PHED, Haryana. Two tube-wells, each of 7.5 HP submersible pumps feed this sump. 35 year old one at 1 km delivers saline water, while 3 yr old pump at 2 km provides fresh drinkable water.

Figure 6. Hand pump or motor connected to main supply line to withdraw water. Even the open street tape has not water pressure to flow.

urban or rural belts are not satisfied with the present scenario and are helpless to do anything more than whatever they are doing. Picture 7-12 show brief glimpses of the situation at Farrukh Nagar which are deteriorating since last 3 decades. The followings are the extract of the locals (agency and people) involvement and perceptions towards sanitation.

Farukh Nagar covers nearly 1 square km area; there are 13 wards each consisting of nearly 700 voters. Overall the city contains a population of nearly 15000 people. Basically household waste and waste from shops are the source of sewage production. There is no sewer system, treatment or outfall in the study area. The domestic wastes being disposed off in abundant house or in open storm drain create problems of pollution, foul and blocking of drains. Side drains and roads get polluted due to putting the wastage here, there and on road/side. The drain is full of dirt, sediment load, and paper/plastic. The long time accumulated water is black and full of foul and toxic elements. However, contract has been given by the municipality centrally for cleaning the town. There is clean-up operation daily in the morning and

Figure 7. Waste Water Disposal Pond of Kentawas.

Figure 8. Another view of Disposal Pond behind Anganwadi at Kentawas.

Figure 9. Mixed cum Sediment and Dirt Loaded Drain of Farrukh Nagar.

putting the dirt from drain on roadside to collect and dispose or burnt partly.

Household wastewater sewerage is combined with storm water drain is. Drain water has no proper escape or outfall. Drain capacity is limited only sufficient to carry the dry weather flow. Even dry weather flow gets overflowed and accumulated over the road. There is no sewer system in the town. There is no treatment unit or outfall point to dispose the waste water. Earlier, funds of

Figure 10. Mixed drain Sewage Overflow Over-road Disposal System.

Figure 11. Storm cum Sewage Drain De-silting Operation.

Figure 12. Typically Clean Municipality of Farrukh Nagar.

nearly 10 million rupees had been sanctioned for sewer but it is not laid due to problem of outfall. Recently big water supply and underground sewer lines projects have come up but the proper study and investigation can only ascertain the effectiveness. People are habituated to live with the existing situation without any individual or group initiative. People are confined to their livelihood and earnings at any cost leisurely.

Households have own system for night-soil disposal but it is not like septic or recharge tank. For the humus/sludge waste a well of nearly 1m in dia and 8 m deep lined by open joint Hume section of 1m length is being constructed. S-trap Pedestal/English type commode is being used. The well of the above dimension is sufficient for 8 to 10 years for night soil of a small (4-5 people) family. The sludge material is pumped in hired tanker from such wells in each 7 to 8 years paying Rs 800 who take it away/ Gurgaon to commercialize, sell or dump. The waste effluent is seeping in the ground. Consequently, there are numerous point source of pollution like this in the region responsible to contaminate the ground water and environment. It is difficult for locals to suggest an alternative, but they remembers that the days of past were better when there was forest and used to go outside. Now, there is no forest. Ground water has gone down. In the past ground water was saline. There was large unit of salt production and supply. Now salinity is decreasing and pollution load is increasing. However, rigorous study is required in this sector as people have hope from experts and helping hands for managed and treated wastewater and sludge disposal system where there is not any natural outfall.

4. Proposed Study Methodology

Being the problem an area specific, the water availability, its quality, treatment, supply strategy and atomization can be defined technologically through formulation of an area specific research plan. In the literature use of flow sensor, GSM modules, pH sensor etc. are suggested. It may be helpful in detecting the leakage and unauthorized taping. Remote Terminal Units (RTU), flow transducers and actuators distributed control and power panels for the pump stations etc. assure real time monitoring of the main technological parameters of large water distribution networks[9].

The project is envisaged to select a suitable populated zone of the study area that is area in and around Farrukh Nagar for demographic study, regional ground and surface water hydrology behavior and pattern (quality, quantity, time series and levels) study, rainwater harvesting, recharge and withdrawal mechanism, purification, storage and supply network within the study area. Methodology shall be employed to collect data as per designed questionnaire and specified instruments. The designed questionnaire shall be aimed to collect stratified socio-economic and technical primary and secondary details from the agencies, records, people perceptions and experts. While the specified instruments based data shall be consists of GIS, Ground water and aquifer details (water level, yield, quality fluctuation and source of pollution), Surface water source, rainfall, water supply system/parameters in the study and nearby areas, etc. Further, analysis of data statistically and employing hydrological and hydraulic software and testing of quality parameters using standard techniques in lab shall be taken up. Various water samples shall be tested for parameters like colour, turbidity, pH, Ca, Mg, iron, chlorides, Fluorides etc to verify with Indian and international standards. Analysis and improvement in water head and distribution network for making the system effective, efficient and free from unauthorized taping, leakage or losses are the need of the hour. Fast purification system is required by reducing the detention or flow through period. The study output and recommendation shall be beneficial to plan and to save the total construction and treatment, O & M costs and time and shall be helpful to provide the sustainable and safe drinking water. Methodology shall be developed to supply fresh and drinkable water along-with daily use water which may meet the national and international standards and demand of the urban and rural population. The following assessment, investigation and developmental study shall be carried out to meet the objective.

The scientific and technological interventions are required to study in detail with the following objectives:

- To assess the status of fresh and safe drinking water scenario in rural and urban locality of the country.
- To review the impact of similar studies, if any completed in the region in the past.
- To investigate the availability and quality of surface and ground waters resources in the area being used over years.
- To study the system, response of the users, community, social activists and government agencies towards their problems and potential regarding water supply.
- To assess the future plan of actions of local citizens and government agencies in the area and to study the gorgeousness and expediency of the proposal.
- To devise suitable methodology for purification, distribution and automation with control system which may be technologically viable, efficient and cost-effective sustainable safe drinking water supply system meeting the demands of all dwellers (rich/poor) in rural/urban environment.
- To have comprehensive study of the system, response of the users, community, social activists and government agencies towards their problems and potential regarding water supply.
- The study shall be supported by workshops in order to provide an adoptable model, as the problem persists all around in the country in same or other form.

Consequently, the study model, modality and results are to be validated through the public/user agencies or service providers, implementing agencies and a brief workshop.

Similar study and investigation regarding status of waste water and sludge disposal are to be taken up. In technical terms a number of tasks associated with identification of options that meet the perceptions and priorities of the locals; feasibility of technical options for potential users; design of infrastructure to meet future demands; information about the costs of options; demand assessment; validation of technical design and levels of service; training and management extension are required. Percentage of households including men and women, boys and girls, elderly, people with disabilities using the sanitation facility whenever needed is an indicator of adequate sanitation. The percentage of households/community excreta carried through a sewer network to a designated location (e.g. treatment facility) or hygienically collected from septic tanks or latrine pits by a suction truck (or similar equipment that limits human contact) and transported to a designated location (e.g. treatment facility or solid waste collection site) or stored on site (e.g. in a sealed latrine pit) until they are safe to handle and reuse (e.g. as an agricultural input) is an indicator of safely managed excreta. A pit latrine shared among no more than 5 families or 30 persons with a superstructure, and a platform or squatting slab may be of different types, i.e. composting latrines, pour-flush latrines, and VIP connected to a septic tank or a sewer.

At national and international level the status of wastewater disposal, treatment and management have been reviewed and found that situation is alarming, solutions are conventional and inadequate, technology are not viable or similar to the entire region. To A preliminary field survey on local practices and facilities available in the region reveals that people are suffering from chronic sewage, sanitation and night-soil problems over last 20 to 40 years. Not only rural areas where there is no municipality except Panchayat of vested interest even urban or semi-urban areas where there is municipality are engaged to earn through contractors on the name of maintenance and keeping the problems everlasting. There is need to give a targeted attention to investigate the problems in details and come-out with a socio-economic and technological viable system. This proposal is devoted to study and investigate the problems and to formulate a technologically viable, modern and sustainable system for waste water management in the study area as a model study and to be beneficial and a guidelines for other regions. Fast purification system is required by reducing the detention or flow through period. Beneficial use of pertinent and sludge as in practice may be needed to develop and improvise in lack of suitable outfall.

The project is envisaged with the aims to select a suitable populated rural, semi-urban and urban study zone, study sewage production quality, quantity and diurnal and periodic/seasonal variations, and manages the system accordingly. The study models will not only save the total construction and treatment cost, O & M cost and time but also provide the beneficial use of sludge disposal and congenial environment. The following objectives completion based study will be carried out:

- To assess the status of household and sewage waste water scenario in rural and urban locality of the country
- To investigate the availability of river, stream, pond or ground water as outfall point and its quality and quantity over years
- To study the system, response of the users, community, social activists and government agencies towards their problems and potential regarding waste water management
- To assess the present and future plan of actions of local citizens and government agencies in the area and to study the gorgeousness and expediency of the proposal
- To devise suitable methodology, technologically viable, efficient and cost-effective sustainable wastewater management system irrespective of status (rich/poor) in rural/urban environment.
- To make the study comprehensive in order to provide an adoptable model, as the problem persists all over in same or other form.

The following major steps are required to be taken to fulfill the objectives.

- To mobilize the resources and conduct literature survey, field visits, reconnaissance survey, sample and data collection.
- To compile data and drawings, analyse data, develop model, upgrade program, prepare physical model.
- To conduct workshop for modernization and management validation and for People participation and awareness.

5. Innovative Issues for Discussion

The following components shall be innovative from fresh drinkable water supply point's of view:

(a) Why drinking water problem is turning towards grievous and chronic?
(b) Why Well are dry? Why tube-wells have to go deeper?
(c) Why fresh water is not available in wells or tube-wells?
(d) Why recharge program is not effective?
(e) Why the fresh water tube-well in adjacent has saline water?
(f) How to use surface water and groundwater conjunctively for water supply to maintain the water table of the region to some extent?
(g) How the saline and fresh water should be supplied to users so the user can get assured amount of fresh water?

(h) Why all households are extracting water from the main supply line?
(i) Why the tape is dry even at ground floor while the supply is through booster pump or an elevated tank? What is the solution to maintain the pressure?
(j) What should be the cheaper way of water treatment for masses?
(k) How individuals and community will take interest to improve the supply system.

Solution to all the above issues are not only area specific but innovative also. Similarly the following components shall be innovative from waste water treatment and disposal point's of view:

(a) Why waste water disposal problem is turning towards grievous and chronic?
(b) Why domestic sewage is mixed with storm water drains?
(c) Why the storm water drain capacity is not adequate and waste water flows or gets accumulated over road?
(d) What are the alternative solutions if there is no conventional source of treatment or outfall point/stream is available to dispose-off the sewage/sludge?
(e) What should be the better option for sewerage?
(f) Storm and sewer water drainage system should be designed separately or combined in the study area?
(g) How the sewage effluent can be treated and reused for specified domestic and agriculture application.
(h) Why all households have well-pit instead of septic tank for night-soil? What are negative effects of this system? What is the sustainable solution?
(i) Why contractors are engaged to manage the sewage disposal system?
(j) How individuals and community will be interested to improve their sewerage system.

Addressing the above issues and solution through scientific and technological intervention are area specific and innovative.

6. Conclusion

Safe, sustainable and viable technology for drinkable water supply is major challenge. Secondly, inland, on-land and water pollution problems are increasing with growth in population, urbanization, change in practices and unplanned development. Sewage water is either left untreated, or being treated partially or disposed off without proper investigation and management. The project is envisaged to select a suitable populated zone and evaluate the adequacy, safety and sustainability of water supply status, future direction for scientific and technologically viable strategy for availability of quality water at door step, sewage collection and disposal system and to evolve methodology for improvised and sustainability managed system. Methodology shall be employed to collect the data as per designed questionnaire and specified instruments. Further, statistical and model analysis employing testing of quality parameters and software shall be taken up. In technical terms, project staffs are likely to be involved in a number of tasks associated with options identification that meet perceptions and priorities of the locals; developing feasible technical options for potential users; designing infrastructure to meet future demands; providing detailed information about the costs of options; demand assessment; validating technical design and levels of service; providing training on future upgrading, management and extension. Study model may be sufficient to meet the national and international standards and demand of the urban and rural population. DST is playing a leading role in supporting and expediting the scientific and technological intervention for viable and sustainable solutions covering the water supply and sanitation related issues of the country. Indeed, we expect the active support of DST in this endeavor. The study project shall facilitated the interested groups of 2nd and 3rd year's students of Urban-cum-Rural Civil and Environmental Engineering in their project work and field studies to improve the amount and quality of drinking water, water purification, disinfection, and distribution and atomization strategy. The help of Electronic, Computer, IT and Applied sciences shall be available in automation and testing events/activities.

7. Acknowledgement

Author acknowledges the support extended and committed by the Dronacharya College of Engineering, Gurgaon and organizers of I^{2}SES-2014 to investigate in details for the benefit of science and society.

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