The Future of Chlorine Disinfectant Choice in Rural Areas

T.Vijaya Prasadini, N.Srinivasu, M.V.Raju

Abstract: According to recent survey 63 Million people in India (which is equal to the population of Australia, Sweden, Bulgaria, Srilanka) have no or lack of access to safe drinking water. This paper reviews briefly about the forms of Chlorine which is used as disinfectant both at the household level and for community water supplies in rural areas. Comparison between different forms of chlorination technologies are also carried out to come up with the most reasonable cost. For surface waters, disinfectant such as solid chlorination (bleaching powder) is followed after sand filtration for rural area water supplies which appears to be the most feasible option. However, difficulties associated with lack of skilled manpower to control chlorine doses and storage of the bleaching powder properly are the main problems often arise. Further, there still a need to develop more reliable and simple methods of disinfection in rural areas

Key Words: Drinking Water, Chlorine, Disinfectant, Rural Water Supply

I. INTRODUCTION

Accessibility and availability of potable drinking water plays pivotal role in health for living beings. Major infectious diseases are transmitted basically from contaminated drinking water especially bacteriological contamination which is majorly contaminated with animal and human excreta. Few microorganisms which cause contamination are Salmonella spp., Shigella spp., pathogenic Escherichia coli, Vibrio Cholerae, Yersinia entercolitica, Campylobacter spp., and various viruses such as Hepatitis A, Hepatitis E, rotavirus and parasites such as Entamoeba histolytica and Giardia spp. when the drinking water is free of all the pathogenic bacteria then it is said to be potable drinking water. The absence of microorganisms with faecal origin is confirmed as microbial safe drinking water. Out of all the other faecal coli forms, E. coli which is a member of the faecal coli form group is a specific indicator of faecal pollution. To ensure the supply of pure and germ-free drinking water to the public, the source has to be regularly monitored disinfectant and pre treatment methods has to be adopted at the supply points. Disinfection of drinking water is one of the main important achievements to ensure weather the drinking water is safe to drink.

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Disinfection inactivates or kills completely disease-causing organisms in water supply schemes and provides 99% bacteriological contamination free drinking water for the welfare of public health. The drinking water schemes add disinfectants to destroy microorganisms which cause diseases in human beings due to Bacteriological contamination. The Surface Water Treatment Rule make sure that the water schemes should disinfect the drinking water obtained from surface water sources and the groundwater sources or sub surface water sources which will be under the influence of surface water. There are so many methods of disinfection technologies which are in practice providing potable drinking water to the public. There are two kinds of disinfection mainly: 1.primary method of disinfection which kills completely or inactivates the microorganisms whereas 2. Secondary method of disinfection maintains their residues which prevent the re-growth of microorganisms in the storage unit even after the supply of water. The Primary methods of disinfection which are practiced are chlorination, ozonization and ultraviolet light. Out of which, Chlorination is the primary and most important method used in most of the rural areas. The use of chlorine for the eradication of microbiological pathogens is essential to protect the public from the blaze of waterborne diseases. In this study, the comparison of various forms of chlorination to the raw water supplied to different public places by various sources of water in and around West Godavari district of southern India was monitored and analyzed

II. DESCRIPTION OF THE STUDY AREA

Geomorphologically the West Godavari district can be divided into two major regions 1.alluvial deltaic region 2. Upland areas. The deltaic region mostly has black soils and the upland areas have the red soil. Polavaram is one of the 48 mandals in West Godavari District of the Indian state of Andhra Pradesh which is an upland area with Red soil. It is located in polavaram mandal of Jangareddygudem revenue division at about 35 km away from the banks of Godavari River. It has population of nearly 50392 with 13677 households as on 2011 census. The total population constitutes 22,345 males and 23,047 females and a sex ratio of 983 females per 1031 males.4846 children in the age group of 0-6 years out of which 2514 boys and 2332 are girls. The literacy rate stands at 23.12 with 9497 literates. Polavaram is located at 17.2500 N 81.6333 E which has average elevation of 16 mts (55 ft), area 28.36Km2 (10.95sq mt).Weather 27°C, Wind E at 8 km/h, 91% Humidity. The Papi hills and polavaram project are the major landmarks near the village.

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Polavaram Project:
In 1980, the Chief Minister of Andhra Pradesh T. Anjaiah laid the foundation stone for the Polavaram project. The project is stalled till the then chief minister of Andhra Pradesh in 2004 restarted the work. YS Rajasekhar Reddy got the required permissions for the projects before he died. For polavaram project, Site clearance was obtained from the Central Government on 19 September 2005, environmental clearance on 25 October 2005, R & R clearance on 17 April 2007, wildlife sanctuary clearance on 19 Sept 2008, forest clearance on 26 Dec 26 2008 and technical advisory committee clearance on 20 January 2009. Later, Polavaram project is declared as national project through AP special re-org act in 2013.

III. OBJECTIVES OF THE STUDY

- Assessment of the water quality at study area and
- Comparison between different forms of chlorination technologies and find out suitable technologies to maintain hygiene environmental conditions for better utilization of water resources

IV. MATERIALS AND METHODS

1. Drinking water-Disinfection: In many drinking water schemes several treatment process such as

a) Coagulation, flocculation and Sedimentation: This is the basic method adopted for Drinking water treatments. This process removes dirt, sand, dust and other particles in raw water. Alum also known as Aluminium sulphate a chemical is added for coagulated solid particles removal which sticks into masses. This sticky mass is called Floc which weight causes the particles to sink or settles to the base of the tank which is called Sedimentation.

b) Filtration: The sedimented particles are forced to filter through sand filtration or activated carbon so that small solid particles that are sedimented and not removed previously will be absorbed and further removed.

c) Disinfectant: In storage, Supply of drinking water from schemes to the public must be kept safe and anti microbial. Frequently, microorganisms especially faecal develop in the distribution system and Over head storage Reservoir (OHSR) .This is a major problem which can be rectified by some disinfectant techniques. Chlorination is one of the best methods designed for the treatment of raw water which helps to kill the micro organisms and also used as a measure of protection against regrowth of microorganisms which cause microbial contamination.

2. Water Sampling: In present investigation, 12 water samples were taken from polavarm. These water samples were collected in polythene one litre bottles which are thoroughly cleaned with diluted acid and rinsed with distilled water. Then water samples were collected for analysis of quality by using standard procedures.

3. Methodology: Few samples were analysed by using analytical instruments. The Physico-Chemical analysis was carried out according to WHO Standard methods. The pH is measured by using HACH pH meter .Electrical conductivity, TDS, Turbidity are measured under MERCK UV Spectrophotometer. Turbidity are measured with Nephelometer. Turbidity is cross checked by MERCK UV Spectrophotometer.H2S Vials Bacteriological test, MPN Count and Total coli forms are tested.

4. Water Treatment Strategy: The Drinking water samples were treated with Chlorination in Three different states i.e... Solid Liquid, Gas. These samples were collected at same mandal where the soil, temperature conditions are similar. Chlorine is applied into the drinking water schemes by mostly three different forms.

a) Calcium Hypo chlorite (Solid) an Inorganic compound which is also called Bleaching powder or chlorinated lime with its formula Ca ($ClO2$).

b) Sodium hypochlorite solution (Liquid) which is also called as Sodium salt of Hypochlorous acid with a Sodium cation and hypochlorite anion and its formula $NaOCl$.

c) Chlorine (Gas) is a second lightest element of the halogens. It is a yellow green gas at room temperature and has highest electro negativity.

The three disinfectant techniques were adopted in three different schemes .Each scheme at different places i.e. Scheme source (Raw water), Treated water, Last tap of the village.

5. Why chlorination is taken for study: For the complete protection from Microbial contamination Chlorine as a disinfectant is more effective. All Disinfectants produce a variety of by products which are chemically risk for the public. The contamination made by the by products produced by many disinfectants is more when compared to the actual microbial contamination. out of all disinfectants ,chlorine based disinfectant is the only one which leave a useful residue in the drinking water which helps in protecting the health of the public by complete control on microbiological contamination, storage and Distribution system.

V. RESUTS AND DISCUSSION

Physical and bacteriological parameters of water samples have been tested which are collected from the study area. Physical parameters that are tested are pH, Turbidity, and TDS where as Bacteriological parameters are H2S Vials test and MPN count. All the results after analysis are compared with WHO standards. Disinfection is definitely the most important process and chlorination is an important approach in protecting drinking water quality.

1. pH: pH of water is a measure of hydrogen ion concentration in water. It balances between hydrogen ion and Hydroxyl ion. As per the WHO standards the pH range for drinking water is in between 6.5-8.5. As it is observed from the test results the pH value is slightly raised in calcium hypo chlorites and sodium hypo chlorites when compared to elemental chlorine. It is also observed that the pH value is excess in calcium hypochlorite. However pH has no direct effect on human health but scale formation is observed in hot water boiling apparatus when abnormal rise in pH value.

2. Turbidity: Turbidity can have negative effects because after chlorination high values of turbidity are observed which is used to kill microorganisms and also to increase chlorine and oxygen demand. As per the WHO standards the Turbidity range for drinking water is in between 1-5 NTU. Turbidity values are within the permissible limits when treated with elemental chlorine. There is a strong relationship between MPN and turbidity was observed by Farooq et

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al. (2008). According to WHO (2011), high levels of turbidity can protect micro organisms from the effects of disinfection, stimulate the growth of bacteria and give rise to a significant chlorine demand. Turbidity values ranged high than the permissible limits as there is a positive relationship with Total coli forms and faecal coli forms especially observed in last tap treated with calcium hypochlorite due to the formation of disinfection by products. Chlorine disinfection by products toxicity is comparatively minimum when compared to other disinfectants.

3. TDS: The water has an ability to dissolve variety of organic and inorganic matters which affects its taste and colour. As per the WHO standards the TDS range for drinking water is in between 500-2000mg/L. In the study area after prechlorination and post chlorination there is no wide change in the ranges of TDS. The concentration of TDS is not harmful.

4. H2S Vials: The H2S Vials test is a simple kit which is used for the primary testing of bacteriological contamination. The process is that the H2S Vial bottle which consists of media is filled with sample water and incubated for 24 hours at 30-350 degrees of temperature. Observe the change in colour of water, if the colour changes to black colour then the water are bacteriological contaminated. The above test results show the slight raw water is having positive test results as the water didn't turn black at 24 hours but at 48 hours with 30-350 degrees of temperature.

5. MPN Test: Most probable number is the estimation of the concentration of microorganisms by using Liquid broth as media. It is used for the testing of bacteriological quality to ensure weather the water is safe bacteriological or not. MPN test is used specially to test the presence of faecal coli forms. In the study there is no abnormal change in the MPN test results. If the presumptive test is negative, no further testing is performed as the drinking water is said to be bacteriological safe. The following are the samples and the analysed results comparison shown in table 1

Table 1. Bacteriological test and Chemical test results at the Study area of Pattisema , Gutala and Polavaram

Sl. No.	Sample Collected Area	Type of Source	Type of Disinfectant Adopted	Type of Water Body	Bacteriological Test		Chemical Test		
					H_2S Vials	MPN	pH	TDS	Turbidity
1	Pattiseema	Surface water	Bleaching powder	Raw water	positive	2/100ml	6.95	657	2
2	Pattiseema	Surface water	Bleaching powder	Treated water	Negative	Nil/100ml	7.34	428	5
3	Pattiseema	Surface water	Bleaching powder	Last tap water (After treatment)	positive	Nil/100ml	7.00	593	6
4	Gutala	Surface water	Liquid Chlorination	Raw water	positive	2/100ml	6.88	680	Nil
5	Gutala	Surface water	Liquid Chlorination	Treated water	Negative	Nil/100ml	6.97	520	Nil
6	Gutala	Surface water	Liquid Chlorination	Last tap water (After treatment)	Negative	Nil/100ml	6.95	500	1
7	Polavaram	Surface water	Gas chlorination	Raw water	positive	Nil/100ml	6.84	137	Nil
8	Polavaram	Surface water	Gas chlorination	Treated water	Negative	Nil/100ml	6.58	116	Nil
9	Polavaram	Surface water	Gas chlorination	Last tap water (After treatment)	Negative	Nil/100ml	6.56	111	Nil

VI. CONCLUSIONS

The study has provided the information about the drinking water quality status at the head works, Source and last tap of polavaram mandal by experimenting various forms of chlorination. Physical Parameters such as pH, TDS, Turbidity were found to be within the WHO permissible limits. Residual chlorine was detected at all the points. However, bacteriological contamination is observed at the raw water. Specially, due to pipeline leakages, repair works total coli form Bacteria is detected in the last tap where Calcium hypochlorite treatment is done. Even though, chlorination with solid works effectively utmost care has to be taken while injecting. Interrupted water supply, unskilled persons who lack training, pipeline leakages, installation, repair works, broken pipes are also one of the reason which increases the bacteria to grow which results the chlorinated water is not observed at the last point.

1. When compared by its cost, the cost of Sodium hypo chlorite and calcium hypo chlorite is two to five times more than elemental chlorine. The calcium hypo chlorite and sodium hypo chlorite has 65 and 15 percent of chlorine respectively. Whereas Elemental chlorine has 100 percent of chlorine in it which is advisable.
2. The equipment used for chlorine gas occupies very little space when compared to other forms of chlorination. For example, if 9000 kg of sodium hypochlorite or 1368 kg of Calcium hypo chlorite is used then only 900Kg chlorine cylinder which contain chlorine gas is needed.
3. When compared to the pumping of chlorine into the drinking water, mixing of Calcium hypochlorite is need utmost care and trained persons which is not done properly in the study areas. Sometimes, Re chlorination is also advised due to improper

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chlorination. Feeding Sodium hypochlorite we have to first convert granular calcium hypochlorite into slurry which requires a metering pump and the process is very risk whereas injecting chlorine through gas chlorinators, usage of ejector helps to send chlorine automatically into the water from cylinders.

4. Feeding rate is low for calcium hypochlorite and sodium hypo chlorite because they degrade fastly as days pass and the strength of the chlorine percent also degrades so the dosage level may not be same for all types of water at all times whereas chlorine gas is again a good choice as there is 100 percent of chlorine in it and will remain in the same strength until the container is empty.

5. The safety of chlorine in gaseous form is neither flammable nor explosive as they are processed in a mounted gas cylinders which contain vacuum and is automatic and system is designed in a way that if there is any failure (which is not at all possible) then they immediately shut down the chlorine release into the air.

It is also observed that the solid and liquid forms of chlorine are added manually. Skin contact with Sodium hypochlorite and Calcium hypo chlorite can damage skin and eyes. The granular form of chlorine can set fire if neglected. Comparison of three forms of chlorination shown in table 2

Table 2. Comparison of Three forms of Chlorination:

Calcium Hypo Chlorite (SOLID)	**Sodium Hypochlorite Solution (LIQUID)**	**Elemental Chlorine (GAS)**
Calcium Hypo chlorite is a white solid which is also called as “Powder chlorine” easily dissolved in water. It has 65 percent of chlorine. Calcium Hypo chlorite is very stable component.	Sodium hypochlorite solution which is also called as “Liquid bleach “is easier to handle. It has 5 to 15 percent of chlorine.	Elemental Chlorine which is also called as “Chlorine gas “is yellow greenish gas with normal pressure. It converts into liquid at high pressures. It is used as both primary and secondary disinfectant. It has 100 percent of chlorine.
Chemicals: Calcium hypochlorite is available in powdered or Granular form. The calcium hypo chlorite with 1 or 2 percent of chlorine is available.	**Chemicals**: Sodium hypochlorite solution is readily available. The Sodium hypochlorite solution is generated by electrolysis of Sodium chloride solution. The Sodium hypo chlorite with 10 or 12 percent of chlorine is available	**Chemicals**: Chlorine gas is supplied in high pressure cylinders
Equipment: The calcium hypo chlorite with 1 or 2 percent of available chlorine is diluted with water and added to the tank which can be done manually. After a transition period of half an hour the drinking water is ready for supply.	**Equipment**: A Hypo chlorinator with Two metering pump where one is used as a standby is used for liquid chlorination. A diffuser is inserted to the pump where it injects the sodium hypochlorite solution into the tank	**Equipment**: A gas chlorinator is installed in a chamber with federal and state safety regulations. The chlorine cylinder is mounted with gas vacuum regulator and chlorine gas is injected directly into the drinking water tank.
Process: The Bleaching powder is diluted with water and added to the tank which can be done manually. After a transition period of half an hour the drinking water is ready for supply.	**Process**: The Sodium hypochlorite solution is injected through the pipe to the tank with adequate mixing and contact time.	**Process**: The Chlorine gas with less pressure is injected through water supply pipe where high pressurized drinking water is mixed with stable contact time. It is necessary to regularly check the pH of the water.
Advantages: 1. It is more stable and is durable for long time. 2. It will react with micro organisms produced by algae. 3. Calcium Hypo Chlorite is effective against micro organisms, protozoa, water borne pathogens.	**Advantages:** 1. It is easy to handle than chlorine in gaseous state. 2. It is less hazardous and will react with micro organisms produced by algae. 3. Sodium Hypo Chlorite is effective against micro organisms, protozoa, water borne pathogens.	**Advantages:** 1. It is more efficient and easy to procure. It acts efficiently of all chlorine based disinfectants. 2. It will react with micro organisms produced by algae. 3. It is reliable and can be easily monitored and highly effective against micro organisms, protozoa, water borne pathogens
Disadvantages: 1. It has to be handled with care as it can be easily evaporated. 2. Calcium Hypo Chlorite is a solid which has to be changed into solution which is complicated. It can contain by products like chlorate, chlorite, and bromite. 3. It is hazardous as it is a corrosive material and have strong odour and it must be kept away from organic materials which causes fire due to heat generation.	**Disadvantages:** 1. It is corrosive to some materials so it should be kept carefully. 2. It is expensive when compared to gas chlorine due to the heavy weight as it is in the form of liquid state. 3. They can’t be stored for longer time as they can be decomposed.	**Disadvantages:** 1. Elemental chlorine is destructive at concentrations as low as 0.1 percent air by volume. 2. It is having pressurised gas which is dangerous, so special handling is needed. 3. Additional regulatory requirements as Occupational safety and health administration process safety management standard are essential.

VII. RECOMMENDATIONS

The following recommendations were suggested after observing the actual position at the study area

1. Re chlorination and regular monitoring should be often done in the areas where chlorination done in granual or slurry form.
2. To check on Bacterial regrowth, regular monitoring of Residual chlorine at Last point of the distribution system is compulsory.

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3. Ensure that the Residual chlorine value is 0.2-0.5 mg/l at the tail end of the distribution system.
4. Regular analysis of physico, chemical and bacteriological
5. parameters must be carried out at different points of the distribution system.
6. The schemes where the chlorination done manually should have skilled persons. Those who are already working still unskilled should be trained.
7. Pipeline leakages, repairs, installation at the distribution line should be rectified immediately.

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