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Design of a Chlorinator in a Water Treatment plant for Small Village Community in Borno State, Nigeria

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ABSTRACT: *The chlorinator is use as a discharge for chlorine which service as a disinfectant of bacterial in the rural water treatment plant in a small village community in Borno State. The percentage of chlorine was evaluated to be approximately 0.00002% which is within the accepted international standard limit for drinking water. The retention time of 5hrs was taken for the tank with volume of 0.0101m^{3}and diameter of 250mm and a calculated height of 206mm, the diameter of the orifice is approximately 1.5mm. Wood was use as the material for the construction of the tank because of its high resistance to chemicals.*

KEY WORDS: *water treatment, chlorinator, chlorine, ozonization*

I. INTRODUCTION

The final process in water engineering is disinfection. This refers to the destruction of water-borne pathogens, which can be accomplished by physical or chemical means. [5]

The wide spread use of rapid sand filters results in a final filtrate of great clarity which is however, not always free of bacteria and other organisms. These have to be reduced, either completely or certainly to a negligible proportion, by some form of disinfection. In practice the vast majority of water works use chlorine compounds, but in some rare cases, it can be done by the addition or certain chemicals, by ozone ultraviolet light or boiling. [1]

The excess lime process of softening kills bacteria. It is not widely used but because of the bactericidal effect of the high PH values incidental to the process, it is occasionally adopted where the raw water is not only hard but also polluted.

Ozonization: Ozonization is also a good means of disinfection and produces high quality water those the process depends on the production on site of Ozone, O_3, by the passage of high tension, high frequency electric discharges through the atmosphere. The Ozone is subsequently absorbed in the water to be treated and has a powerful bacterial action without imparting taste to the water. It is a costly process needing skilled maintenance and may not yet be considered suitable for adoption in smaller village communities in preference to chlorination. In addition to its high cost it suffers from the fact that ozone is not very persistent and water treated by this method at source might be re-infected at a later stage in the distribution system [l].

Boiling: Raising water to its boiling point will disinfect it. Because no important water borne disease is caused by spore forming bacteria or other heat resistant organisms, this is a safe and commendable practice where drinking water safety is suspected. It is re-sorted to also as an emergency measure in the form of boiling water always by health water authorities. [5]

Sunlight: Sunlight is a natural disinfectant principally as a desiccant. Irradiation ultraviolet light intensifies disinfection and makes it a manageable undertaking, but other sources of ultraviolet light may be used such as mercury-vapour lamps to intensify the disinfection. [5]

II. CHLORINATION

Bleaching powder (Chlorinated lime) and sodium hypochlorite of different commercial brands are widely used for sterilizing small water supplies. For rural schemes a solution made from bleaching powder is more convenient. It has 20% to 25% available chlorine and is easy to handle although bulky and comparatively instable. If opened once a day for 10min, 5% of its strength is lost in 40 days, if left open all the time, it will lose 15% of its strength, it could be used in simple chlorinating ports these are pots charge with an equal weight mixture of bleaching powder and sand. Solution is kept in dark as there is a serious loss of strength if they are exposed to light. Containers should be made of wood, plastics, ceramics or cement, which are resistant to corrosion. The maximum chlorine concentration is 5% made by mixing 4kg of powder having 25% chlorine, with 20 liters of water [6]. The injection of the bleaching powder is by gravity feed or by special chlorine pumps. In clear water 0.5-1.0mg/1 of free residual chlorine should ensure sterilization. Doses of this magnitude are used on the small, unsophisticated works for which this method is suitable [I].

In most modern works of any size chlorine gas is used, chlorine is supplied as a liquefied gas in cylinders or drums and injected into the water through a chlorinator. The chlorinator is a fairly complicated apparatus which reduces the pressure of the gas leaving the cylinders, controls the rate of flow, mixes water and delivers it to the pump or injector which forces it into the filtered water. Since chlorine is very corrosive, all piping and pumps have to be of suitable resistant materials [5].

In hot environment such as Maiduguri and its surrounding villages, the rate at which the gas leaves the cylinders is too high, the rapid transition from liquid to gas causes extremely low temperatures. Therefore, the hotter the weather the greater is the risk of freezing (or formation of crystals) within the tube between the cylinder and chlorinators [5].

III. DESIGN OF CHLORINATOR

For designing of the chlorinating tank, the required concentrated solution of bleach and water in the chlorinator that will be diluted with the water in the filter sump to give the required (0.00002% to 0.00005%) free chlorine which is acceptable standard for drinking must be known.

As earlier stated the concentration of bleach for drinking purposes is 0.5mg per litre of free chlorine i.e. (0.00002% to 0.00005%). For 2% concentration of chlorine in solution, 100ml of bleach is diluted in 10 litres of water that is, $0.0001m^3$ of bleach is diluted in $0.01m^3$ of water. Hence the total volume of 2% concentrated solution of free chlorine in the chlorinator is $0.0001m^3$ of bleach + $0.01m^3$ of water = $0.0101m^3$.

Thus volume of chlorinating tank V = $0.0101m^3$

For a chlorinating tank diameter of 250mm, and from

Volume (v) $= \frac{\pi d^2}{4} \times h$

Where h is height of tank and d is the diameter.

It follows that h = $\frac{0.0101 \times 4}{\pi \times 0.025^2}$ = 0.206m = 206mm.

Hence the chlorinator is 250mm diameter and 206mm deep.

For a retention time of 5hrs, the discharge Q = $\frac{\text{volume}}{\text{time}} = \frac{V}{T}$

Thus, Q $= \frac{0.0101}{5 \times 3600}$ = $5.6\text{x } 10^{-7} m^3/s$. which is the discharge from the chlorinator, also from Q = cd a $\sqrt{2gh}$

Where cd is coefficient of discharge through orifice (cd <1) is area of outlet orifice.

It follows that a = $\frac{Q}{cd\sqrt{2gh}}$

The cd for small circular orifice is 0.4

$$a = \frac{5.6 \times 10^{-7}}{0.5\sqrt{19.62 \times 0.206}}$$

a = $5.571 \times 10^{-7} m^2$, but a = $\frac{\pi d^2}{4}$

$d^2 = \frac{4 \times 5.571 \times 10^{-7}}{\pi}$ = 7.093 x 10-7

d = 0.0011m=1.1mm

Hence diameter of orifice d ≅ 1.5mm is selected

Percentage free chlorine in the solution of 5.6 x $10^{-7}m^3$ of 2% chlorine and $0.003m^3$ of water per second will be $(\frac{5.6 \times 10^{-7}}{0.003}) \times 100 \times \frac{1}{1000} = 0.000018\% \cong 0.00002\%$

It can be seen that the percentage free chlorine in the solution that will be formed in the filtered water sump per second is 0.00002% which is within the accepted drinking range of 0.00002% to 0.00005%.

IV. MATERIAL SELECTION AND SPECIFICATIONS

The material selected for the chlorinator is wood, which could be locally carved into the required dimension and also provided with a means of mounting to the top of the filter as shown in the diagram.

Wood is selected because of its high resistance to chemicals especially as the tank is to contain a 2% solution of chlorine. The wood should be also carved with a suitable cover so as to reduce loss of strength of the solution.

During shutdowns or repairs the tube connecting the chlorinator and the filtered water tank can be constricted by means of a clip valve to stop flow. The diameter of pipe from the filtered water sump is 0.1m (100mm) and is properly painted to avoid corrosion.

V. CONCLUSION

The need for portable drinking water in our rural communities cannot be over emphasize. The cheapest and most easily adaptable method of disinfecting water in such communities is chlorination. Other methods such as Ozonization could also be integrated into the process as a future alternation means of disinfecting water.

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