Prof → 04 Environmental engineering

Disinfection

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Defn → destruction or inactivation harmful substance present in water.

→ the chemical added for the killing of harmful ~~substance~~ substances is known as disinfectant.

* Good quality of disinfectant →

(1) It kills the present existing bacteria (it takes of the present contamination)

(2) It should take care future recontamination (i.e it should have residual capacity)

Disinfection

→ kills the pathogenic bacteria

Sterilization

→ kills all type of harmful as well as harmless substances present in water by the process of boiling.

Minor methods of disinfection

(1) Boiling of water
(2) Addition of lime
(3) Treatment with UV Rays
(4) Treatment with ozone
(5) Treatment with Bromine and Iodine pills.
(6) Treatment with Kmno4 / potassium permagnent)
(7) Treatment with Silver by electro kataydn process.

① Boiling the water →

→ Removes the present existing bateria. but does not take care of future recontamination.
→ kills the micro-organisms
→ It is uneconomical.
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→ It is uneconomical.

② Addition of lime →

$CaO \rightarrow Ca(OH)_2$

pH > 9.5, causes alkalinity.

(i) addition of lime leads to pH > 9.5 causes alkanity.

(ii) Recarbonation is done to remove alkalinity.

(iii) Dosage of lime 14 - 40 mg/l, then it reduces bacterial load by 99.3% - 100%.

(iv) doesn't take care of future recontamination.

(3) Treatment with UV (ultraviolet ray) quartz bulbs → sterilised water
→ it does impart any taste in water.
~~→ cost~~
→ highly costly

→ electric current is passed through mercury enclosed in quartz bulbs
→ used in small community swimming pools.

(4) Treatment with ozone (O_3)

$O_3 \rightarrow O_2 + [O]$

([O] = nascent oxygen, highly unstable)

→ It is powerful oxidising agent and removes organic matter.

* Advantages of ozone.

(i) It removes colour, odour & organic matter.

(ii) It gives pleasent taste to water.

* Disadvantage.

→ Does not have residual capacity

→ Dosage of O_3 is 2 to 3 ppm so, that

→ It has a residual capacity of 0.1 ppm, when it is in a contact period of 10 minutes.

→ 'Ozoniser' → apparatus / equipment used for producing ozone is very costly.

(5) Treatment with Bromine & Iodine pills → upto 8 ppm

→ kills present existing bacteria.

doesn't take care of future recontamination handy

Treatment with KMnO4 ⇒
basically used in Rural area.

Dosage ⇒ 1 to 2 ppm
4 to 6 hrs

⇒ 98% bacteria
⇒ 100% ⇒ bacteria (Cholera)

Treatment with KMnO4 ⇒

(1) It is a power disinfectant for well water supplies in villages which are contaminated with lesser amount of bacteria.

(2) Besides killing bacteria, it also helps in oxidising the taste producing organic matter, hence it is sometimes added to even filtered and chlorinated water.

(3) KMnO4 is mixed with water in a bucket and added

to well. pink colour forms because of this, of pink colour disappears. this implies that organic matter is present. Hence more kmno4 is added until the pink colour stands. the well is not used for next 48 hours.

(4) Dosage is normally 1 to 2 mg/l and the contact period is 4 to 6 hrs.

(5) It removes 98% bacteria (approx) but removes 100%, bacteria causing cholera.

(6) Water treatment with kmno4 with the passage of time produces dark brown precipitate.

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*(7) Treatment with Silver ⇒ or Electro Catalydn process

⇒ algae
⇒ germicidal action.
* Dosage ⇒ 0.05 — 0.1 mg/l.
→ 15 min — 3 hours.
⇒ highly costly (so it does not used generally)

Treatment with Silver or Electro katadyn process

→ Strong germicidal action
→ Dosage 0.05 – 0.1 mg/L
→ contact period may vary from 15 minutes to 3 hours.
→ neither imparts any taste and odour to the water nor it produces any harmful effect on human body.
→ the method, however removes algae and its germicidal property is retained for a considerable time, thus safeguard against future recontamination.
→ But it is highly costly, hence not used for PWDs (Public water distribution Systems)

* chlorination →

(1) It kills the present existing bacteria

(ii) It poses residual capacity

$Cl_2 + H_2O \underset{}{\overset{PH>5}{\rightleftharpoons}} HOCl + HCl$

(Hypochlorous acid)

$HOCl \underset{PH<7}{\overset{PH>8}{\rightleftharpoons}} H^+ + OCl^-$

(hypochlorite ion)

* HOCl is 80% more powerful than OCl^-
* HOCl is highly unstable.

K = reaction rate constant or ionisation constant.

$$K = \frac{[H^+][OCl^-]}{[HOCl]}$$

→ $(HOCl + OCl^-)$ & Cl_2 = freely available chlorine

v.v.v.g

$$\frac{[HOCl]}{[HOCl + OCl^-]} = \frac{1}{1 + \frac{Ic}{[H^+]}}$$

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* H^+ → Hydrogen ion concentration in moles/litre.

(1) If pH < 5.5, 100% HOCl, Nil OCl^-

(2) If 5.5 < pH < 9.5, 50% HOCl, 50% OCl^-

(3) If pH > 9.5, 100% OCl^-, Nil HOCl.

* $NH_3 + HOCl \xrightarrow{pH > 7.5} NH_2Cl + H_2O$ (Monochloramine)

→ $NH_2Cl + HOCl \xrightarrow{pH\ 5-6.5} NHCl_2 + H_2O$ (dichloramine)

→ $NHCl_2 + HOCl \xrightarrow{pH < 4.4} NCl_3 + H_2O$ (trichloramine)

* Various Forms of Chlorine

(1) Free chlorine
(2) Bleaching powder or hypochlorite
(3) Chloroamines

(i) Free chlorine → (liquid or gaseous)

* liquid or gaseous.
* temperature → 32°C - 45°C
* If L 10°C → blocked by calcium
* Equipement → Chlorinator.

(2) Bleaching powder →

$Ca(OCl)_2 \longrightarrow Ca^{2+} + 2OCl^-$

$OCl^- + H^+ \xrightarrow{pH < 7} HOCl$

pH > 8

(3) Chloramines → 25 times slower as compared to free chlorine.

→ phenol is present.

* Chlorine dioxide (ClO_2) →

→ 2.5 times faster as compared to free chlorine

→ $NaClO_2 + Cl_2 \rightarrow NaCl + 2ClO_2$

→ HOCl > ClO_2 > Cl_2 > Chloroamines

(1) free chlorine → (drycard) gaseous form

(i) liquid form is most widely use.

(ii) If temperature below 10°C liquid chlorine will get frozen into ice crystal which will stick and choke the lines of feeding.

Hence, liquid cylinder is kept at 32°–45°C.

(iii) chlorine forms explosive mixture with carbon monoxide

(iv) chlorine is applied Through as equipment called chlorinator

(v) Free chlorine can be stored for long time without being distructed.

(vi) No sludges is formed.

* Hypochloride & Bleaching powder

(1) $Ca(OCl)_2 \rightleftharpoons Ca^{2+} + 2OCl^-$

$OCl^- + H^+ \underset{pH > 8}{\overset{pH < 7}{\rightleftharpoons}} HOCl.$

→ HOCl and OCl^- are disinfectant in this case. This process is called hypochlorination

→ Hypochlorination are generally not used in modern days, as they increase the pH, since they poses lime content.

→ Hypochloride contain very low amount of chlorine.

→ It is used for swimming pools only.

→ Hypochloride ion used $Ca(OH)_2$ leads to formation of sludge, while carrying out disinfection hence not used for treatment.

* chloroamines →

(1) chloroamine are weather disinfectants (25 times weaker) than hypochlorine Hence other higher dose of larger contact period is required.

(2) Chloroamines stable and can remain in water for a long time containing to unstable chlorine which evaporates after sometime Hence they provide greater safeguard against future pollution

(3) they are weaker as compared to free chlorine but donot bad taste when left as residue

(4) When phenol is present to water chloroamine are mostly used because chlorine with Phenol gives bad taste But chloramines with phenol does not give any taste

(5) Ammonia adding equipment is known as Ammoniator.

* **chlorine dioxide →**

(1) It is highly effective (25 times stronger than free chlorine)

(2) $2NaClO_2 + Cl_2 \rightarrow 2NaCl + 2ClO_2$

(3) It may also be used when phenol is present and can remove organic

(4) pH. range is 8-10

(5) Normal dose is 0.5 – 1.5 mg/l

* On the basis of effective more

HOCl > ClO_2 > Cl_2 > chloroamines

* Types of chlorination and certain important definition →

→ depending upon the quantity of chlorine added & the stage at which it is added or upon the results of chlorination, various; they are following types.

(I) plain chlorination
(II) pre-chlorination
(III) post-chlorination.
(IV) double chlorination.
(V) break point chlorination.
(VI) super chlorination
(VII) dechlorination.

(I) plain chlorination → This term is used to indicates that only the chlorine treatment and no other treatment has been given to the raw water. under plain chlorination, therefore raw water is fed into the distribution systems after giving chlorine treatment only.
→ This help in removing bacteria, organic matter, and colour from the raw water.

This technique may be used for treating relatively clearer water (with turbidities less than 20 to 30 mg/l) obtained from lakes, reservoir etc.

→ It may also be used during emergencies, when full-fledged treatment cannot be given, such as for supplying water to army troops during war times.

→ The used quantity of chlorine required for plain chlorination is about 0.5 mg/l or more

(11) Pre-Chlorination → pre-chlorination is the process of applying chlorine to the water before filtration or rather before sedimentation-coagulation. It helps in improving coagulation and reduces the loads on the filters.

→ It also reduces the taste, odour, algae and other organisms.

→ The chlorine dose should be such that about 0.1 to 0.5 mg/l of residual chlorine comes to the filter plant.

→ The normal doses required are as high as 5 to 10 mg/l.

→ pre-chlorination is however always followed by post chlorination so, as to ensure the final safety of water.

(iii) post chlorination → post chlorination or sometimes simply called chlorination is the normal standard process of applying chlorine in the end, when all other treatment have been completed.

→ the post chlorination is adopted after filtration and before the water enters the distribution system.

→ the dosage of chlorination should be such as to leave a residual chlorine of about 0.1 to 0.2 mg/l, after a contact period of about 20 minutes.

→ This residual will ensure the disinfection of water.

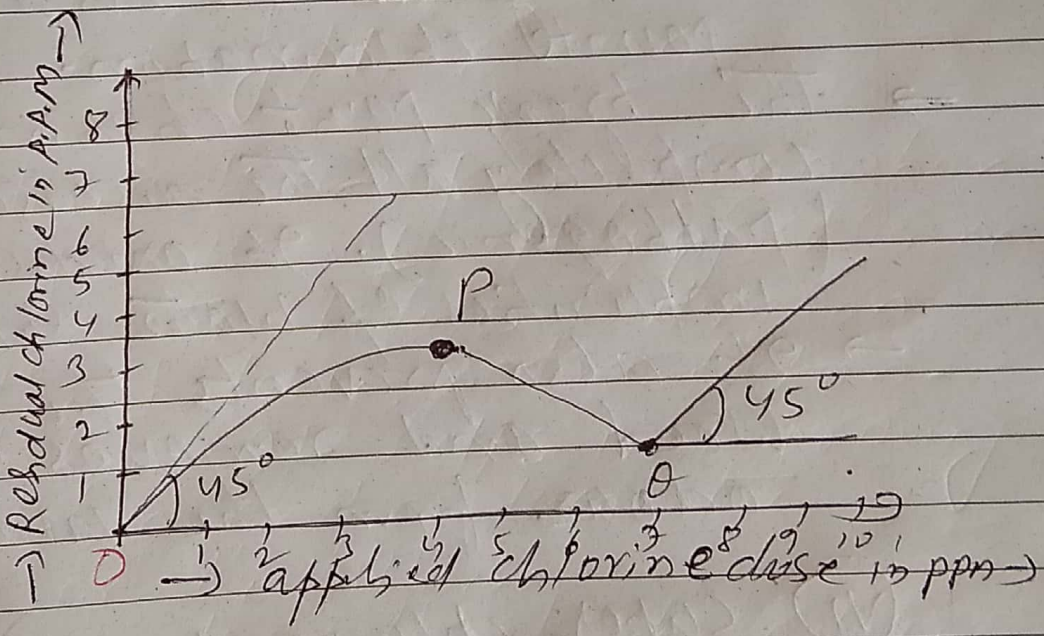
(iv) double chlorination → the term double chlorination is used to indicate that the water has been chlorinated twice.

→ the prechlorination and post chlorination are generally used in double chlorination.

→ post chlorination, however is generally always used

while the pre-chlorination is also used when the water are highly turbid and contaminated.
→ its advantages are the same as those of pre-chlorination. In addition, the second unit of chlorination plant required for pre-chlorination may serve as a stand by unit for emergencies.

V.V.I (v). **Break point chlorination** →



→ When the chlorine dose increase, the combined available chlorine also increase. on further increase of chlorine the compounded get oxidised and the substance which are newly formed donot react to show any residual. this phenomene is called break point.

→ This is shown by. from the figure, we see that the residual chlorine in the beginning increases with the applied chlorine dose. But after point 'P', it suddenly drops upto point 'O' and then increases. This portion OP shows the formation of chloramines and the portion PQ shows their oxidation.

→ the point 'O' at which the residual chlorine again starts increasing is known as break point chlorination.

→ the break point chlorination destroys completely all the disease bacteria (pathogenic). It oxidises the impurities of water such as ammonia

→ It also prevents the growth of weed and removes taste and odour from the water.

(VI) Super chlorination → When chlorine is added in excess of that required for adequate bacteria purification of water, it is called super chlorination. This is done under certain circumstances such as epidemics of water born diseases.

A high dose of chlorine (i.e 2 to 3 ppm) is added to water beyond break point for safety of public

Dechlorination → the removal of unwanted chlorine in water by chemical or physical treatment is known as dechlorination. the most commonly used chemical for the dechlorination of water are Sulphure dioxide, sodium bisulphate, sodium thiosulphate, activated carbon, potassium permanganate etc.