

Detergents and Disinfectants

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Cleaning and disinfection operations are integral parts of food production. Product quality will be greatly affected if these operations are not carried out properly. During cleaning operations, soil is removed by applying detergent. The presence of soil decreases the efficiency of disinfectants. The cleaner the surface, the more effective will be the disinfectant. Disinfection should follow immediately after cleaning.

Detergents

Detergent is a substance which assists in cleaning. The different types of substances to be removed in food processing plants are mainly bits of food particles containing sugar, fat, protein, mineral salts etc. and grease. Detergents used in food processing plants must be capable of removing these types of substances.

Ideally, detergents should be: 1. Readily soluble in water 2. Non corrosive 3. Non irritating to the skin and eyes 4. Non-toxic 5. Odourless 6. Biodegradable 7. Economical 8. Stable during storage and 9. Capable of removing all types of soil.

In order to remove all types of dirty substances, detergents should have the following properties.

- a. In order to wet the surface, detergents should lower the surface tension of water. Then the water can penetrate the soil more readily and remove it from the surface to be cleaned.
- b. Detergents should disperse insoluble materials that might otherwise form aggregates.
- c. Detergents should dissolve soluble dirt
- d. It should emulsify fats & oils
- e. It should saponify fats

- f. Removal or inactivation (sequestering) of calcium and magnesium salts dissolved in water. When calcium and magnesium salts are removed or inactivated, their precipitation is prevented and the cleaning efficiency is not affected.

Since no single chemical possesses all the above properties, different chemicals are blended together to form detergent formulations of the correct balance for a particular cleaning need.

Classification of detergents

Detergents may be classified into four groups: 1. Inorganic alkalis 2. Inorganic and organic acids 3. Surface active agents and 4. Sequestering agents

1. Inorganic alkalis

Inorganic alkalis used as detergents are sodium hydroxide, sodium metasilicate, sodium orthosilicate, sodium sesquisilicate, sodium carbonate, trisodium phosphate (TSP) etc. Sodium hydroxide is cheap, has excellent dissolving properties and is a strong saponifier. But, it is highly corrosive to metals and can cause severe burns to the skin. Sodium metasilicate has good dispersive and emulsifying properties. It is readily rinsable but relatively expensive. Sodium metasilicate is less corrosive than sodium hydroxide. Since sodium metasilicate suppresses the corrosive activity of sodium hydroxide, the two are often combined together in detergents. Sodium orthosilicate and sodium sesquisilicate have good saponification powers and both are effective cleaners of protein material. Both are corrosive to aluminium. Sodium carbonate (soda ash) is a weak detergent, but it is cheap. Trisodium phosphate is a good emulsifier and saponifier. It has strong dispersive properties. Sodium carbonate and trisodium phosphate are moderately corrosive and are often incorporated in detergents. All the alkaline detergents precipitate calcium and magnesium salts from hard water. Hence, sequestering agents are incorporated with alkali cleaners in any detergent formulation.

2. Inorganic and organic acids

Detergents belonging to inorganic acids are hydrochloric, sulphuric, nitric, phosphoric and sulphamic acids. Organic acids which have been incorporated in detergent formulations are gluconic, hydroxyacetic and tartaric acids. The organic acids are usually milder than the inorganic acids. Acids are not generally used in the food industry as they are corrosive and they lack versatility as cleaners. Most of them can cause severe skin burns.

3. Surface active agents

Surface active agents reduce the surface tension of water to facilitate wetting. Soap reduces the surface tension of water and hence is a surface active agent. Soap is the sodium or potassium salt of fatty acids. Reduced solubility in hot water is a disadvantage of soap. Soaps are effective in soft water. But soap forms precipitates with calcium in hard water. Hence soaps have been largely replaced by synthetic detergents. Synthetic detergents may be divided into four groups: anionic, cationic, non-ionic and amphoteric. The classification is based on their active electrical charge when dissolved in water. When negative charges predominate, the surfactant is termed as anionic surface active agent. When positive charges predominate, it is named as cationic. When surfactants do not dissociate in solution, they are termed as non-ionic. Where the predominant charge varies according to whether acidic or alkaline conditions prevail, the surfactant is termed amphoteric.

Molecular formula of surface active agents have two portions: a hydrophilic (water loving) portion and a hydrophobic (water hating) portion. The hydrophobic portion is lipophilic too. The hydrophilic portion is attracted by water and the other end is attracted by fat and oil. Thus a bond is established between water and oil. This is the basis of the cleaning action of surfactants.

Hundreds of surfactants are incorporated into detergent formulations. Surface active agents have good wetting and penetrating powers. They are excellent emulsifying agents. They are non-corrosive, non-irritating

and readily rinsable. They are highly soluble in cold water and are unaffected by hard water.

- a. Anionic surface active agents: Most synthetic detergents (syndets) are of the anionic type. They are alkyl benzene sulphonate, alkyl sulphates and alkyl ethoxy sulphates. Anionic surfactants cannot be combined with cationic detergents.
- b. Cationic surface active agents: Cationic syndets are quarternary base compounds. They are more expensive. But some are germicidal! For this reason, the cationic surfactants are used as disinfectants and sterilizers.
- c. Non-ionic surface active agents: Commercially important non-ionic syndets are alkyl ethoxylates, the ethoxylated alkyl phenols, the fatty acid ethanol amides etc. Non-ionic surfactants are used as disinfectants and sterilizers.
- d. Amphoteric surface active agents: Amphoteric syndets can exist in solution in either the anionic or the cationic form depending on the pH. They have the general formula $R-NH-CH_2-COOH$ where R is usually an alkyl radical. They lack some of the desirable properties of detergents and hence have a limited range of uses.

4. Sequestering agents

Sequestering agents are generally added to detergents to prevent salt precipitation. The amount of sequesterant added depends on the extent of water hardness. Some of the inorganic sequestering agents are tetrasodium pyrophosphate, sodium tripolyphosphate, sodium tetrphosphate and sodium hexametaphosphate. Organic sequestering agents are ethylene diamine tetra acetic acid (EDTA), nitrilo triacetic acid (NTA), their sodium and potassium salts and the sodium salts of gluconic and heptonic acids.

Disinfectants

A disinfectant may be defined as an agent capable of destroying a very wide range of microorganisms but not necessarily bacterial spores.

The aim of a disinfectant is to reduce the number of microorganisms to such an extent that those remaining cannot affect the microbiological quality of the food coming into contact with these surfaces. Desirable properties of disinfectants for use on food contact surfaces are the following. 1. Capable of rapidly killing microorganisms. The disinfectant should be equally effective against both Gram-positive and Gram-negative bacteria. The majority of mould spores should be killed. The destruction of bacterial spores would be an added advantage. 2. Reasonably stable in presence of organic residues. 3. Effective in presence of hard water salts 4. Non-corrosive 5. Non-staining to plant surfaces 6. Odourless or have an inoffensive odour 7. Non-toxic 8. Non-irritating to the skin and eyes 9. Readily soluble in water 10. Readily rinsable 11. Stable during prolonged storage in concentrated form 12. Stable during short-term storage in dilute form 13. Economical.

Classification of disinfectants

Disinfectants used in the food processing industry may be classified into 1. Chlorine and chlorine compounds, 2. Quarternary ammonium compounds, 3. Iodophors and 4. Amphoteric compounds.

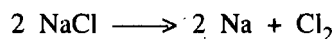
Pine oil disinfectants and phenolic compounds can be used for disinfecting floors, gutters etc. particularly when there is no work in the food processing hall.

1. Chlorine and chlorine compounds

In-plant chlorination has become popular in the seafood processing industry for process control and maintenance of good manufacturing practices.

a. Gaseous chlorine

Common salt is the most important source of chlorine. It is produced by the electrolysis of brine. In simple form, the reaction can be represented by the following equation.



But, there are various secondary reactions. Hence, special electrolytic cells and methods may have to be used to obtain a good yield of chlorine.

Chlorine is a greenish yellow gas with pungent odour. It causes irritation when inhaled. If chlorine is present in the atmosphere in more than traces, it can give rise to serious damage to lungs and other tissues finally resulting in death. At atmospheric pressure, it is 2 ½ times heavier than air. Hence, leaking chlorine gas tends to collect near the floor level. In the presence of moisture it is very corrosive to metals. Chlorine is slightly soluble in water, the solubility being about 1 per cent at 10°C. As the temperature increases, the solubility decreases and it becomes zero at 100°C. For commercial distribution, chlorine is compressed to liquid form and transported in steel cylinders.

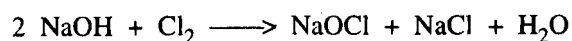
b. Hypochlorites

Hypochlorites are salts of hypochlorous acids. These salts are unstable in the pure form. Decomposition of hypochlorites is accelerated by the presence of acids and delayed by alkalis. Therefore stabilisation is obtained by admixture with excess alkali. Sodium and calcium hypochlorites are widely used for chlorination of industrial waters.

i. Sodium hypochlorite (bleach liquor)

Comparatively weak hypochlorite solutions (1 per cent available chlorine) can be prepared by the electrolysis of brine. During electrolysis, first sodium and chlorine are produced. Sodium reacts with water forming sodium hydroxide. The cells are arranged in such a way that chlorine formed during electrolysis reacts with the sodium hydroxide forming sodium hypochlorite.

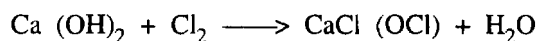
Sodium hypochlorite solutions can also be prepared by passing chlorine gas into a solution of caustic soda. The reaction can be represented by the following equation:



Sufficiently excess alkali is retained so that the pH of the solution is always maintained around 11, thus improving stability. The percentage of available chlorine in the solution is upto 10 per cent w/v. The solutions keep reasonably well if packed in black polythene carbuoys and stored at refrigerated temperatures.

ii. Calcium hypochlorite (bleaching powder)

Bleaching powder is produced by the action of chlorine on slaked lime. The reaction can be represented by the following equation:



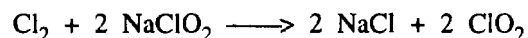
This reaction is not completed in practice and about 50 percent of lime remains free in the final product. Presence of excess of lime improves the stability of the product.

The precautions to be taken during the storage of hypochlorites are the following:

1. Containers for bleaching powder should have tight seals and should be stored in a cool place, because the chlorine is loosely combined.
2. Since sodium hypochlorite solutions contain excess of sodium hydroxide, containers for these solutions should be non metallic.
3. Since hypochlorites are decomposed by sunlight, hypochlorite solutions should be stored in amber glass or crockery bottles.
4. In order to prevent caking and subsequent loss of chlorine, bleaching power should be kept in moisture - free areas.

c. Chlorine dioxide

For the purification of water, chlorine dioxide is generated by the action of chlorine on sodium chlorite.

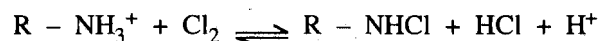


The gas is unstable and must be used immediately after generation. Chlorine dioxide is very much soluble in water - 46 percent at 30°C.

Chlorine dioxide is used to control tastes and odours due to phenolic contamination of waters. It can also be used to remove tastes and odours caused by algae, weeds etc. Chlorine dioxide converts iron and manganese in water rapidly to insoluble forms. It is comparatively stable in water and hence its action is long lasting. It is unaffected by ammonia and has been found to be an effective germicide where there is considerable organic matter in the water.

d. Chloramines

Chloramines are formed by the reaction of chlorine with the nitrogen in the ammonium ion.



This is a reversible reaction. Chloramines are less active oxidising and germicidal agents than chlorine. Since they are more stable, an active residue remains for a much longer period (several days) in the treated water. Hence, chloramines are particularly useful where a long contact time is preferred.

e. Methods of chlorination

There are two important chlorination methods: marginal chlorination and super-chlorination with or without dechlorination. The latter includes break-point chlorination and in-plant chlorination.

Factors influencing sterilization of water by chlorine

There are several important factors concerned with the successful chlorination of water.

i. Condition of water. The water to be chlorinated should be free from suspended matter. Suspended matter absorbs chlorine and protects bacteria. Bacteria may be embodied in the particles. Thus, bacteria is

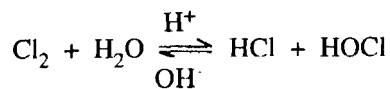
protected from action by chlorine. Certain impurities of water such as protein, other nitrogenous compounds, sulphides, nitrites and iron absorb or destroy chlorine. Hence their demands must be satisfied before any chlorine is available for germicidal action.

Chlorine demand = ppm of chlorine
added - ppm of residual chlorine observed

Free and saline ammonia reacts with chlorine forming chloramines. Chloramines are less active germicidal agents than chlorine. Hence, traces of free and saline ammonia cause considerable retardation of sterilization.

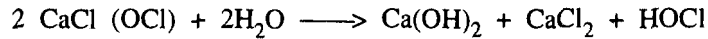
ii. Temperature. Temperature has a noticeable effect on chlorination. The time required for a given chlorine concentration to kill 99% of the bacterial cells in a solution is reduced by about 50% for each 10°C rise in temperature. Residual reactions persist longer if the temperature of water is less.

iii. Hydrogen ion concentration. When chlorine is passed through water, the following reaction takes place:

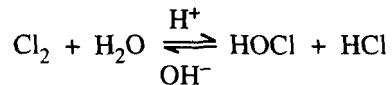


The forward reaction is favoured by the hydrogen ion concentration and the reverse reaction by hydroxide ions. Thus, the amount of HOCl present in a solution decreases with increase in pH. The speed at which chlorine kills bacteria is directly proportional to the concentration of unionised HOCl in solution. Hence, the higher the pH, the slower the bactericidal action.

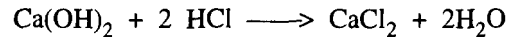
When chlorine gas is passed through water, hypochlorous acid and hydrochloric acid are formed. Hydrochloric acid reduces the pH of water thereby increasing the germicidal activity. But when hypochlorites are added to water, the corresponding chlorides and hydroxides are formed along with hypochlorous acid.



Hypochlorous acid decomposes forming chlorine. The chlorine dissolves in water forming hypochlorous acid and hydrochloric acid.



The HCl reacts with hydroxide formed during the addition of hypochlorite to water.



The amount of HCl produced is only sufficient to neutralise half the alkali formed. This free alkali raises the pH thereby lowering germicidal power. Thus, chlorine gas decreases the pH of water, while hypochlorite increases the pH during chlorination.

iv. Dosage and contact time. The amount of chlorine added to water is called the chlorine dosage. This value is usually expressed as parts per million (ppm). The chlorine dosage for any water should be in excess of the immediate demands of the impurities in water. The chlorine remaining after satisfying the demand of water (total residual chlorine) will be available for germicidal action. Since the destruction of bacteria is not instantaneous, an adequate contact time must be allowed. There is an inverse correlation between residual chlorine and contact time. The rate at which bacteria are killed is directly related to the concentration of chlorine in water. The higher the concentration of chlorine, faster will be the rate at which the bacteria are killed.

Marginal chlorination

Marginal chlorination is the addition of just sufficient chlorine to water to produce a residual level. The residual chlorine may be either free or combined depending on the amount of ammonia present in the water. This level of chlorination usually destroys pathogens.

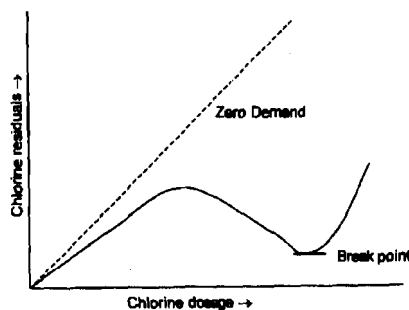
Superchlorination

The chlorine dosage applied is much greater than that of marginal chlorination. The chlorine dosage depends on the character of the water and the purpose for which the water is used. A considerable amount of chlorine may be present after a given contact period. Therefore, for certain purposes, the water is dechlorinated. Superchlorination includes break-point chlorination and in-plant chlorination.

i. Break-point chlorination

When small amounts of chlorine are added to water, first, chlorine reacts with certain impurities present in the water. These impurities are substances responsible for chlorine demand. Chlorine reacts with nitrogenous compounds to form chloramines or other chloronitrogen compounds. On further addition of chlorine, a free residual of chlorine appears. On still further addition, the free residual of chlorine gradually increases until it reaches a particular concentration. The concentration of free chlorine is determined by the physical and chemical nature of the water. When the level of free chlorine is increased beyond this concentration, oxidation reaction occurs between free chlorine and chloronitrogen compounds.

The level of the free residual chlorine is decreased during the oxidation of chloro-nitrogen compounds. When the oxidation is completed, the addition of chlorine to water results in corresponding increase in chlorine concentration. The point after the first rise in concentration at which the free residual reaches its lowest level is known as the break-point.



The advantages of break-point chlorination are the following:

- * Complete oxidation of ammonia and other compounds in the water
- * Correction of tastes and odours of biological origin
- * Correction of tastes and odours due to phenol and other substances
- * Reduction of colour due to organic matter
- * Improvement of bacterial quality of water

ii. In-plant chlorination

In-plant chlorination has been defined as break-point chlorination of all water as it enters the plant to a degree where a good persisting residual of chlorine occurs. In-plant chlorination of processing water is employed in many food industries. The levels of chlorine required in water during the various stages of processing seafood are given in Annexure-I.

Chlorine gas is generally considered the best source for in-plant chlorination where large volumes of water are to be chlorinated. But for chlorination by chlorine gas, a chlorination equipment is needed. Hypochlorites are a good source when only small amounts of chlorine are required. Since seafood processing industry requires only small amounts of chlorine, hypochlorites can be used by the industry. In water chlorination, bleaching powder is made into a suspension with small quantity of water, the solids allowed to settle, and the clear supernatant solution then added to the water to be treated. Since the lime sludge retains a portion of the chlorine, it is advisable to allow 10 per cent for this loss in calculating the requirements. Since this process is inconvenient, it is practically confined to emergency treatment. In the case of sodium hypochlorite solution, it can be directly added to the water to be chlorinated. Hence sodium hypochlorite solution is generally used by the fish processors in India for chlorination of water.

The available chlorine content of sodium hypochlorite solutions from the market varies with different samples. The method for the estimation of available chlorine in sodium hypochlorite solution is as follows. For strong solution, pipette 10 ml into a 250 ml graduated flask containing

about 100 ml of distilled water, keeping the tip of the pipette beneath the surface of the water. Dilute to the mark and mix thoroughly. Use a measured portion for the determination. For weak solutions (below 3.5% available chlorine) use the sample as received. Dissolve 2-3 gms of potassium iodide crystals in 50 ml of distilled water in a 250 ml Erlenmeyer flask. Introduce the sample under the surface of the solution. (The volume of the sample should be such that it will titrate about 40.0 ml of N/10 sodium thiosulphate solution). Acidify slightly with acetic acid.

Titrate with N/10 sodium thiosulphate until the yellow colour of iodine is nearly destroyed. Add 5 ml of starch solution and titrate until the blue colour entirely disappears.

Available chlorine in sodium hypochlorite

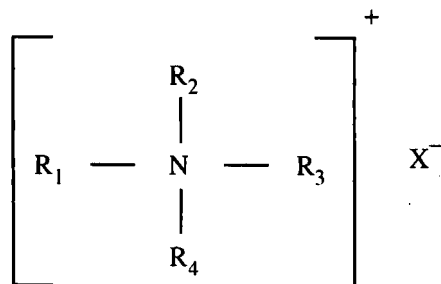
$$\text{solution} = \frac{\text{ml N/10 sodium thiosulphate} \times 0.3546 \% \text{ (W/V)}}{\text{ml of sample}}$$

Water of different chlorine levels can be prepared with the help of the chart given in Annexure-II.

No allowance for the chlorine demand of the water to be chlorinated is given in the chart. The level of chlorine present in the water can be measured with the help of 'Chlorine level indicator paper' (Chlorine level indicator paper is produced by Glaxo India Limited as per CIFT technology under the trade name 'Cloritest papers' which is available in the market). More quantity of sodium hypochlorite solution is added if the level of chlorine present in the water is low.

2. Quaternary ammonium compounds

When some or all hydrogen atoms in the $(\text{NH}_4)^+$ ion of ammonium salts are substituted by alkyl or aryl groups, quaternary ammonium compounds (QACs) are formed. The general formula of quaternary ammonium compounds is the following:



where R₁, R₂, R₃ and R₄ represent one or more alkyl or aryl groups and X⁻ represents Cl⁻ or Br⁻. The cation is the active part of the molecule, while the anion influences the solubility of the compound. Examples of QAC disinfectants are cetyltrimethyl ammonium bromide and lauryldimethylbenzyl ammonium chloride. They are very active bactericides against Gram-positive bacteria. Unless sequestrants are present they are less effective against Gram-negative forms. They are non-corrosive, non-irritating to the skin and stable even in dilute solutions. Since QACs are cationic surfactants, they cannot be used in conjunction with anionic surfactants. In comparison with hypochlorites, they are more expensive.

3. Iodophors

Iodophors (iodo means iodine and phor means carrier) are soluble mixtures of iodine with a surfactant. The surfactant acts as a carrier for the iodine, while iodine imparts bactericidal activity. Since iodophors are very active in a pH range of 3-5, phosphoric acid is added to the iodophor in order to lower the pH of the solution. Iodophors effect rapid killing of a broad spectrum of bacteria. They are stable in concentrated form. Iodophors are non-corrosive, non-irritating, non-toxic and have little smell. But they must be rinsed off after use. Rubber and some plastic materials may absorb the iodine. Iodophors are expensive and hence are not used widely. Iodophors are used mainly in dairies, since in addition to their bactericidal power, the phosphoric acid is useful in the control of milkstone.

Pine oil disinfectants

Pine oil disinfectants are effective against pathogenic microorganisms which cause communicable diseases. This is the principal function of this class of disinfectants. In addition, they possess cleaning and penetrating properties and also have a pleasant odour.

Pine oil is not soluble in water. Hence it is used in the emulsion form. The commercial disinfectant is a mixture of pine oil, emulsifier and water. The emulsifying agent most commonly used is rosin soap. Soaps other than rosin soap can also be used. Rosin (4 parts) is dissolved in pine oil (10 parts) by heating. Then a 25 per cent solution of sodium hydroxide (2 parts) is added and the mixture heated until the saponification is completed. A clear yellow, homogenous solution is obtained which upon the addition of water, gives a white milky emulsion. Instead of soaps, synthetic detergents such as Teepol, Whittol etc. can also be used as the emulsifying agent.

The ability of pine oil emulsions to kill organisms of communicable diseases makes them well suited for use on floors of fish landing places, primary processing centres and factory premises. But the disinfectant should not be sprayed on surfaces coming in contact with fish. Pine oil disinfectants have fly repellent properties. Since they are having a pleasing odour, they can also be used as an odour counteractant.

Phenolic compounds

Many phenolic compounds are widely used as general-purpose disinfectants, as they have strong bactericidal powers. But they are seldom used in food processing plants because of their strong odour.

Annexure - I

Recommended level of available chlorine in water used for seafood processing

Stage of processing	Recommended level of available chlorine
The water used in the processing plant	5-10 ppm
For ice manufacture	5-10 ppm
For washing contaminated ice before using with the fish	5-10 ppm
The disinfect the fish processing factories and primary processing centres after applying a suitable detergent (contact time : 15 mins)	100 ppm
To disinfect floor surface, gutters etc.	500-800 ppm
For final washing	10 ppm
To disinfect boat decks, fish holds, wooden boxes etc. (contact time : 4-5 mins.)	1000 ppm
For spraying fish containers, fish carrier vans and refrigerated wagons in order to remove fish smell	100 ppm
To disinfect washed utensils coming in contact with seafood (immersion time 4-5 mins.)	100 ppm
To disinfect workers' washed hands	200 ppm
For cooling cooked frozen prawns	20 ppm
For dipping the material before packing (dipping time - 10 mins.)	20 ppm
For glazing cooked frozen prawns	10 ppm
For reglazing cooked frozen prawns	20 ppm
For cooling processed cans	3 to 5 ppm

Annexure - II

How to chlorinate water correctly

The correct quantities of sodium hypochlorite to be taken in case of samples of different concentrations to chlorinate known volume of water at two different levels (5 ppm & 100 ppm) are given below :

Qty. of water in litres	Quantity of sodium hypochlorite required (in millilitres)				
	Sodium hypochlorite of concentration				
	1%	2%	3%	4%	5%
	To chlorinate at the levels of				
	5 ppm 100 ppm	5 ppm 100 ppm	5 ppm 100 ppm	5 ppm 100 ppm	5 ppm 100 ppm
1	0.50 10	0.25 5	0.16 3.20	0.12 2.50	0.10 2
2	1.00 20	0.50 10	0.32 6.40	0.25 5.00	0.20 4
3	1.50 30	0.75 15	0.48 9.60	0.37 7.50	0.30 6
4	2.00 40	1.00 20	0.64 12.80	0.50 10.00	0.40 8
5	2.50 50	1.25 25	0.80 16.00	0.62 12.50	0.50 10
6	3.00 60	1.50 30	0.96 19.20	0.75 15.00	0.60 12
7	3.50 70	1.75 35	1.12 22.40	0.87 17.50	0.70 14
8	4.00 80	2.00 40	1.28 25.60	1.00 20	0.80 16
9	4.50 90	2.25 45	1.44 28.80	1.12 22.50	0.90 18
10	5.00 100	2.50 50	1.60 32	1.25 25	1.00 20

20	10.00 200	5.00 100	3.20 64	2.50 50	2.00 40
30	15.00 300	7.50 150	4.80 96	3.75 75	3.00 60
40	20.00 400	10.00 200	6.40 128	5.00 100	4.00 80
50	25.00 500	12.50 250	8.00 160	6.25 125	5.00 100
60	30.00 600	15.00 300	9.60 192	7.50 150	6.00 120
70	35.00 700	17.50 350	11.20 224	8.75 175	7.00 140
80	40.00 800	20.00 400	12.80 256	10.00 200	8.00 160
90	45.00 900	22.50 450	14.40 288	11.25 225	9.00 180
100	50.00 1000	25.00 500	16.00 320	12.50 250	10.00 200
Oty. of water in litres	6%	7%	8%	9%	10%
	5 ppm 100 ppm	5 ppm 100 ppm	5 ppm 100 ppm	5 ppm 100 ppm	5 ppm 100 ppm
1	0.08 1.60	0.07 1.40	0.06 1.25	0.05 1.10	0.05 1
2	0.16 3.20	0.14 2.80	0.12 2.50	0.11 2.20	0.10 2
3	0.24 4.80	0.21 4.20	0.18 3.60	0.16 3.20	0.15 3
4	0.32 6.40	0.28 5.60	0.25 5.00	0.22 4.40	0.20 4

5	0.40 8	0.35 7	0.31 6.25	0.27 5.50	0.25 5
6	0.48 9.60	0.42 8.40	0.37 7.50	0.33 6.60	0.30 6
7	0.56 11.20	0.49 9.80	0.43 8.75	0.38 7.70	0.35 7
8	0.64 12.80	0.56 11.20	0.50 10	0.44 8.80	0.40 8
9	0.72 14.40	0.63 12.60	0.56 11.25	0.49 9.90	0.45 9
10	0.80 16	0.70 14	0.62 12.50	0.55 11	0.50 10
20	1.60 32	1.40 28	1.25 25	1.10 22	1.00 20
30	2.40 48	2.10 42	1.87 37.5	1.65 33	1.50 30
40	3.20 64	2.80 56	2.50 50	2.20 44	2.00 40
50	4.00 80	3.50 70	3.12 62.5	2.75 55	2.50 50
60	4.80 96	4.20 84	3.75 75	3.30 66	3.00 60
70	5.60 112	4.90 98	4.87 87.5	3.85 77	3.50 70
80	6.40 128	5.60 112	5.00 100	4.40 88	4.00 80
90	7.20 144	6.30 126	5.62 112.5	4.95 99	4.50 90
100	8.00 160	7.00 140	6.25 125	5.50 110	5.00 100