

WATER IN SEAFOOD PROCESSING

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Abstract

The quality requirements of process water in seafood processing are discussed with emphasis on their physical, chemical, bacteriological and biological characteristics.

Introduction

Water is used for a number of purposes in the food industry. It may come into contact with the product during manufacturing processes; it is used for cooling purposes, for washing equipments, in boilers and heating systems, and it may be an integral component of the final product. The impurities it carries have an important influence on the characteristics of many foodstuffs in which it has been used as an ingredient. The chances of contamination of public waters have increased due to urbanization, industrialisation and intensive agriculture. High population growth rates are responsible for the accelerated generation of waste and waste waters. These wastes and waste waters increase health hazard from biological contaminants discharged into natural water courses. Similarly, rapid industrialization is responsible for the discharge of large amounts of chemical pollutants into public waters. Pollution in connection

with agricultural activities may arise from animal wastes (including infectious agents), sediments from land, plant nutrients, pesticides and inorganic salts, and minerals resulting from irrigation.

Seafood processing requires a copious supply of potable water. On an average 12 litres of water are required to process one kilogram of seafood. This indicates the extent of risk involved in using non-potable water. In recent years there has been a gradual increase in the number of requests for analysis of water and ice used in our seafood processing industry at the instance of the foreign buyers. This article, it is felt, will give the interested processors the necessary information on the quality requirements for water used in seafood processing.

The significances of the examination of water

Water is generally examined for four types of characteristics: Physical, chemical, bacteriological and biological. Physical examination is necessary since the presence of any noticeable colour, odour or taste makes the water unpotable. Chemical examination is indispensable for eliminating such dangers as lead solvency, the presence of poisonous substances, for determining

the hardness and suitability of the water for domestic and industrial purposes. The chief function of the bacteriological examination is the detection of faecal pollution. Biological examinations are necessary to deal with problems concerning taste, odour and filterability, arising from the growth of algae when water is stored in reservoirs.

I. Physical characteristics :

The main physical characteristics for which a water is examined are: appearance, colour, turbidity, odour, taste and pH.

Process water in seafood plants should have no noticeable colour, which is the product of impurity of one kind or another. The most common colours encountered are yellow and brown, usually due to the presence of organic matter. Yellowish-red tint may be due to the presence of traces of iron and red-brown colour may be due to peat. Sewage effluents have a slight yellow colour. Biological growths, such as algae impart various colours to waters, of which green and blue-green are the most common and colloidal manganese and iron impart brown colour. Water containing traces of copper when comes in contact with alkaline materials such as soap may sometimes impart green colouration to water. The discharge of industrial wastes or the disposal of dye containing wastes may impart colour to the water.

Process water should be of such quality that they produce no sensation of taste or odour. Although the presence of odours are always accompanied by the presence of tastes, it is possible for waters to possess taste without odour. When this occurs it is usually

due to the presence of an excess of certain saline or mineral constituents. Common salt imparts brackish taste if present in more than 175 ppm (parts per million) of sodium chloride, while waters having high contents of sodium sulphate may be described as saline. Bitter taste of water may be due to the presence of iron, manganese, aluminium sulphate or excess lime.

The presence of hydrogen sulphide, probably produced by the bacterial reduction of sulphates in water, imparts odour to the water. Contact of water with painted surfaces such as bituminous linings of tanks gives rise to taste and odour. Contamination by organic matter from sewage, manure, soil and vegetation imparts taste and odour to water. Growth of living matter such as algae, protozoa, fungi etc., in water produces taste and odour. Chlorophenol taste is produced from traces of phenols present in water when chlorinated.

Undissolved materials in water include inorganic substances such as rock dusts, clay, salt, silica, ferric hydroxide, calcium carbonate, sulphur etc. and organic substances such as vegetable and animal matter, oils, fats, greases, and micro-organisms. Size of undissolved materials may be in the colloidal range or as large as grains of sand. The larger granules settle down rapidly in quiescent water and are seen as sediment while the more finely divided particles remain suspended and are responsible for turbidity.

Water can be divided into three distinct classes on the basis of the pH value. They are :

- (a) pH 8 and above. The water in this group contains no free carbon

dioxide but carbonates, with or without bicarbonates.

- (b) Above pH 4.5 but below pH 8. The water in this class contains no carbonates, but contains free carbon dioxide and bicarbonates.
- (c) pH 4.5 and below. The water in this class contains some free acids besides carbon dioxide. Waters having pH values above 8.5 and below 4.5 are generally corrosive. Sewages and sewage effluents are generally neutral or faintly alkaline. Factory effluents are often acidic. Mineral acids can be present in sufficient amounts in waters of low pH to impart a distinctly sour taste.

II. Chemical characteristics :

Chemical characteristic may be divided into five groups :

1. Main mineral constituents.
2. Constituents relating to the organic quality of water.
3. Metals.
4. Toxic substances and
5. Radio-active substances.

1. Main mineral constituents

The main characteristics under this group are total dissolved solids, hardness, alkalinity, chlorides and sulphates.

An estimation of the total solids affords a valuable check on the results of the more detailed analysis, while a qualitative or semi quantitative estimation affords information with regard to the quality of the water. When large blocks of ice are prepared, the minerals dissolved in the water tend to concentrate in a core of eutectic com-

position, that, when solidified, becomes undesirably cloudy in appearance. Removal of the core and replacement by fresh water can be resorted to as a means of obtaining uniformly clear blocks. The total dissolved solid content should not exceed 300 ppm. for clear transparent ice.

In good water the residue left on evaporation over the water bath is free of colour. On stronger heating, charring of the residue indicates the presence of organic matter. If the charring is accompanied by a disagreeable odour, the organic matter may be of animal origin. The presence of iron is usually indicated by a brown tint, rendered more evident upon ignition.

Hardness of water is due to the presence of bicarbonates, sulphates and chlorides of calcium and magnesium. Water is classified in terms of hardness. Annexure-I shows this classification. Disadvantages of hard water are soap wastage, the production of adherent slime or curd in wash basins, baths and on textiles being laundered and the formation of scale or fur in boilers, hot water pipes, and household utensils. An exceedingly soft water may have action on lead, zinc and iron.

The bicarbonates are decomposed by heat, carbon dioxide being evolved and insoluble calcium carbonate precipitated. Hardness of this character is called carbonate or temporary hardness and is responsible for the scale formation in boilers, kitchen utensils etc. The hardness remaining after boiling is termed non-carbonate or permanent hardness. If the amount of bicarbonate does not exceed 100ppm, the insoluble carbonate formed does not form scale, but comes out of solution as a sludge

which can be removed by blowing down. The chlorides of calcium and magnesium have a corroding effect on steam boilers due to the formation of hydrochloric acid in steam and is undesirable for boilers and other manufacturing equipments. Water containing much magnesium chloride is undesirable for canning purposes, since it increases the risk of struvite formation. Struvite is magnesium ammonium phosphate which sometimes forms crystals resembling bits of glass in fish cans. If possible sea-water should be avoided for washing fish before canning, since sea-water contains magnesium compounds. Calcium sulphate does not deposit unless the water is concentrated; on concentration it crystallises on the boiler plates as a scale which is often difficult to remove, even by mechanical means.

Alkalinity above 100 ppm (expressed as calcium carbonate) adversely affect the quality of the frozen fishery products, the defect being bleaching on cooking.

In most waters the whole of the chloride present is in combination with sodium as sodium chloride; occasionally calcium and magnesium chlorides are also present. Potassium chloride in appreciable amount is usually found only in mineral waters. Near the sea, the influx of sea water will be indicated by an increase in chlorides and hardness. If water contains a large amount of chlorides and a correspondingly large amount of nitrates, the origin may be said to be of sewage

Water containing large amounts of sulphates causes diarrhoea, especially amongst children.

2. Constituents relating to the organic quality of the water

The characteristics in the group are free and saline ammonia, albuminoid ammonia, nitrate, nitrite, biochemical oxygen demand, chemical oxygen demand, amonic surfactants, carbon chloroform extract etc.

Almost all the natural waters contain some traces of ammonium salts. By distillation of such waters the ammonia is carried over in the distillate. This ammonia is spoken of as free ammonia (free and saline ammonia). A further quantity of ammonia can be obtained by adding a strong alkaline solution of potassium permanganate to the concentrated water and continuing the distillation. This latter quantity is called the albuminoid ammonia which is produced by the oxidation and hydrolysis of the nitrogenous organic matter present in the water,

Some of the various sources from which free and saline ammonia may be derived are the following: Rain water contains traces, the first fall containing the most. All fertile soils and all decaying vegetable and animal matter contain free ammonia. Nitrifying organisms convert free ammonia into nitrates, while ferruginous sands convert nitrates into ammonia. Urine of man and animals yields large quantities of ammonium carbonate, hence sewage is rich in free ammonia.

Estimation of albuminoid ammonia is the most sensitive chemical test for organic pollution, when taken in conjunction with the free and saline ammonia, nitrate and nitrite contents. The free ammonia and albuminoid ammonia contents should be considered

together, since their relative proportion is more important than the actual quantities. The reasons are discussed below. In all sewages and many sewage effluents the amount of free ammonia greatly exceeds that of the albuminoid ammonia. In the crude sewage the free ammonia is $2\frac{1}{2}$ times as great as the albuminoid ammonia. Hence in many cases sewage pollution is indicated, when a natural or untreated water yields more free ammonia than albuminoid ammonia. Decaying vegetable matter in a water yields more albuminoid ammonia than free ammonia. During chlorination of water, if organic matter is present in water, its demand must be satisfied before any chlorine is available for germicidal action; presence of free and saline ammonia in amounts more than traces cause considerable retardation of sterilisation.

Nitrates are present in most waters. Their only concern with purity and wholesomeness relates to considerations of pollution by sewage or manure, since they may be derived from the oxidation of nitrogenous organic matter of animal origin. The more efficient the progress of sewage purification, the less is the amount of nitrogen as free ammonia, and the greater the amount of nitrogen as nitrites and nitrates. Water which contains any excess of nitrates, and is liable to become turbid or opalescent after a heavy rain, may be regarded as unsafe for food industry. It is better to conduct a bacteriological examination of such waters the sample being taken a day or two after a heavy rainfall, in order to ascertain whether both soil purification and filtration are efficient. Since nitrate in water causes cyanosis in babies, the water used for preparation of infant

foods should contain not more than 20 ppm of nitrate nitrogen.

For water containing greater amounts of organic matter the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) tests are useful. The BOD test measures the amount of dissolved oxygen required by living organisms for the aerobic destruction or use of organic matter, while the COD test measures the oxygen, equivalent of that portion of the organic matter in a sample which is susceptible to oxidation by a strong oxidizer. If wastes contain toxic substances, the latter test may be the practical method for determining the organic load.

The vastly increasing use of synthetic detergents has resulted in the possibility of anionic surfactants reaching waters used for drinking purposes. As the most widely used surfactant is alkyl benzene sulphonate (ABS), it is the one most likely to be present in water supplies.

Organic contaminants—natural substances, insecticides, herbicides and other agricultural chemicals—enter streams from run off. Increasing industrialization has resulted in the possibility of many different organic chemicals reaching waters used for drinking purpose. Some of the contaminants are extremely persistent and hence only partially removed by treatments. This organic contaminants can cause health hazards. In order to effect a closer examination of organic matter in waters the carbon chloroform extract (CCE) test has been suggested. The taste and odour of the water is generally poor when the CCE test records a value above 0.2 ppm.

3. Metals

Apart from the main cautions present in water, viz. calcium, magnesium, sodium and potassium, iron, manganese, zinc and copper are also encountered.

Iron in excess of 0.3 ppm can cause water to appear as rusty. The presence of iron and manganese in water is objectionable owing to the production of discolouration, turbidity, deposit and taste. Ferruginous waters have an astringent, metallic or bitter taste. Even traces of iron and manganese in water lead to the accumulation of appreciable deposits in distribution lines and reservoirs. Under such conditions growth of iron bacteria often develop in the distribution system when difficulties such as blocking of mains, pipes etc. are accentuated and the water becomes discoloured and turbid. Poisoning due to the manganese in drinking water is rare. Turbidity may be developed when waters containing much zinc salts are boiled. Zinc salts are poisonous only in very large doses. Copper salts in natural surface waters occur in trace amounts. Their presence beyond this level is an indication of pollution. When meant for canning operations, the copper level should be less than 0.1 ppm, as higher amounts may cause blackening especially in the case of shrimp. The presence of copper or iron in water used for processing fatty fishes is not advisable since these may hasten the rancidity development of such fishes.

4. Toxic substances

The main characteristics in the group are fluoride, cyanide, lead, arsenic, hexavalent chromium, silver, selenium, cadmium and barium.

Traces of fluorine are present in most waters. It has been established that the presence or incorporation of a small amount of fluoride in drinking water reduces the incidence of dental carries in growing children. Mottled enamel, a defect in teeth has been attributed to fluoride in drinking water. The minimum quantity of fluoride in water to give rise to mottled enamel is from 1 to 2 ppm. Fluoride in relatively large doses causes skeletal changes too. Cyanide may occur in waste water from chemical industries such as electroplating. Although cyanide is extremely poisonous, very small quantities may be harmless, as it is converted to the relatively non-toxic thiocyanate and excreted.

Lead is a cumulative poison. Certain natural waters contains traces of lead in solution, waters of certain composition rapidly take up lead from lead pipes and lead lined cisterns. Natural environmental sources of lead are enhanced by industrial ones. Tetramethyl lead is a large source in areas where automobile exhaust contributes lead to the environment. The symptoms of chronic lead poisoning are constipation, loss of appetite, abdominal pain associated with pain and tenderness of the muscles and a gradual paralysis. Arsenic is also a cumulative poison. Many natural waters are known to contain arsenic. This is never sought for in an ordinary analysis. Tests would only be applied if there were reasons to suspect its presence. A detectable trace would condemn any water as unfit for drinking purposes. Cancers of the skin and liver have been attributed to arsenic in the domestic water supply in several instances. Toxicity of chromium is confined to hexavalent compounds of chromium.

Silver is cumulatively stored in the body. Excessive intake of silver may lead to argyria (a permanent disfigurement in the form of a darkening of the skin). Selenium is one of the essential elements and is also labelled as a carcinogen. The symptoms of chronic selenium toxicity in man are depression, languor, nervousness, occasional dermatitis, gastrointestinal disturbances, giddiness and garlic odour of the breath and sweat. Cadmium is considered an element of high toxic potential. It accumulates with age and concentrates in the kidneys and livers. Human beings dying from the effects of hypertension show abnormal quantities of cadmium in their kidneys. Cadmium in drinking water causes *Itai-Itai* disease, characterised by softening of the bones and shrinking of the body. Barium is considered as a toxic substance due to its toxic effects on the heart, blood vessels, and nerves.

Forty samples of water from different processing factories in Kerala were analysed for the above mentioned toxic substances during the period 1974-75. It was found that these toxic substances were practically absent or far below the limits. In fact, in this respect, we can be quite confident that water used in this area is free from toxic substances.

5. Radioactivity in water

Radioactive materials often have very long decay time and any adverse health effects they create are almost always very much delayed and hence a cause/effect relationship is difficult to establish. Opinions differ widely about the risks posed by radioactive pollution. There are five classes of radiation which may affect public health and water supplies.

a) Alpha particles: These are positively charged particles identical with helium nuclei. If an element liberating them is deposited in any organ of the human body, it will give off these particles and may cause extensive damage.

b) Beta particles: These are electrons negatively charged of variable penetrating power.

c) Gamma rays: These are highly dangerous rays due to their long range and highly penetrating power.

d) Neutrons: These are uncharged highly penetrating particles which induce radioactivity.

e) X-rays: These are electromagnetic radiations of very short wave length. Over-exposure to X-rays may cause serious damage to living human and animal tissue.

The important natural sources of radioactivity are from the elements potassium, radium, uranium and thorium. Then there are cosmic rays from the outer space. Some radioactive isotopes are also created continuously in nature out of stable atoms; carbon-14 and hydrogen-3 (tritium) by bombardment of stable atoms with cosmic rays in the upper atmosphere. The chances of contamination of water by radioactive wastes has increased due to the construction of atomic piles and power plants and, the extensive use of radioactive materials in medicine, research and industry. Another source of radioactivity is in the form of radioactive dust brought down by rain and derived from experimental nuclear explosions.

Dangerous isotopes which are carried by water are mainly strontium and

radium. Strontium-90 is concentrated in the bones of the body and may give rise to tumours or blood diseases such as leukemia and anaemia. Radium-226 is the most dangerous isotope. Ingestion of large amounts had led to severe anaemia, haemorrhages and infections. The long term effect of radiation is the genetic one.

Radioactivity is measured in terms of the number of disintegrations per unit of time. The disintegration rate of radium is taken as the standard. The unit of radio-activity is called curie. It is defined as the quantity of any radioactive material having associated with it 3.7×10^{10} disintegrations per second. One gram of radium has an activity of one curie.

III. The Bacteriological examination of water

Contamination by sewage or by human excrement is the greatest danger associated with drinking water. If such contamination has occurred and if among the contributors there are carriers of infectious diseases the water can cause these diseases such as typhoid fever and dysentery. Sewage-polluted water may also contain the viruses of poliomyelitis, other viruses of the Enterovirus group, or the virus of infectious hepatitis. Animals and birds may carry human intestinal organisms, pathogenic to man. The use of contaminated water for the preparation of food may allow the multiplication of intestinal pathogens and hence is harmful.

The direct search for the presence of specific pathogenic bacteria or viruses in water is impracticable for routine control purposes. Pathogens present in water are usually greatly outnumbered by the normal intestinal

organisms. These pathogens tend to die out more rapidly. It is possible to isolate pathogens from water. But their isolation and identification are laborious and time consuming. The isolation of viruses requires even more difficult and lengthy procedures. Bacteriologists have therefore evolved simple and rapid tests for the detection of normal intestinal organisms such as coliforms, faecal streptococci and *Clostridium perfringens* (*Clostridium welchii*). These organisms are easier to isolate and identify. The presence of normal faecal organisms in a water sample indicates that pathogens could be present. The absence of faecal organisms indicates that pathogens also are probably absent.

The organisms most commonly used as indicators of faecal contamination are the coliform group as a whole, and particularly *Escherichia coli* which is the most frequent type of coliform organism present in human and animal intestine, numbering upto 100 or even 100 millions per gram of fresh faeces. Apart from excretal contaminations, it is rarely found in soil, vegetation or water. Coliform organisms other than *E. coli* also occur in the intestinal canal. But their combined numbers seldom exceed one million organisms per gram of fresh faeces. The distribution of coliform organisms in nature suggests that they may all be primarily faecal organisms but that outside the body types other than *E. coli* have greater powers of survival and can multiply in certain circumstances.

The greatest value of the test for faecal streptococci lies in assessing the significance of doubtful results from the test for coliforms, particularly the occurrence of large numbers of coli-

forms, in the absence of *E. coli*. The presence of streptococci would confirm the faecal origin of the pollution.

The test for *Clostridium perfringens* has uses similar and additional to the examination for faecal streptococci. *Clostridium perfringens* forms spores which survive for a much longer time than the vegetative organisms of the coliform group. The presence of *Clostridium perfringens* in a natural water indicates that faecal contamination has occurred. The presence of *Clostridium perfringens* in the absence of coliform organisms indicates that the contamination has occurred at some remote time. In the absence of *E. coli*, the occurrence of *Clostridium perfringens* in water together with other coliform organisms suggest that faecal pollution has not been recent.

Colony counts are not essential for assessing the safety of domestic water supplies. They are useful for indicating the efficiency of certain processes in water treatment, and the cleanliness of the distribution system. In some water supplies, rising colony counts may give the earliest sign of pollution. They are also useful for determining the suitability of a water supply for large scale preparation of food and drink. In these cases the water should ideally contain few organisms of any kind in order to avoid the risk of spoilage. During canning cans are cooled by water either inside or outside the retort. Then care should be taken to ensure that the water used is good. As the cans are cooled, pressure inside falls rapidly and under such conditions even a correctly made seam may allow the passage of traces of water which, if contaminated, may give rise to spoilage during subsequent storage.

Presence of lipolytic bacteria in the water used for processing food especially those containing fat can cause hydrolysis of fat with the liberation of free fatty acids (FFA) affecting the quality of the product. Proteolytic bacteria will decompose the protein present in the food leading to putrefaction. Slime-forming bacteria release slime, which is a polysaccharide, into the water. This slime if present in cooling water will decrease the efficiency of cooling.

The treatment of water to make it potable involves the physical removal of enteric pathogens or their chemical destruction. Chlorine gas, liquid chlorine, and various chlorine compounds have been employed for the treatment of public water supplies. Free chlorine has a bactericidal power upto two hundred times that of phenol. The firmness with which the chlorine is bound to other substances or elements determines how effective the chlorine is going to be in killing the organisms. Loosely bound chlorine, such as that found in calcium hypochlorite, can be active in killing them. Chlorine can combine directly with proteins in a process called chlorination, or it may effect oxidation. In both cases, the normal protoplasmic balance in the cells is disrupted and it eventually dies. The concentration of chlorine required to disinfect water satisfactorily is usually not above 1 ppm, with a residual level of 0.1 to 0.3 ppm at distant points through out the distribution system.

In-plant chlorination of processing water is employed in many food industries. In cannery and freezing plant the in-plant chlorination of processing water aids in reducing bacterial

load throughout the plant. Chlorination makes it easier to remove slime that may have developed on plant equipment. This is due to the fact that such slime as may have developed does not adhere tenaciously. So a thorough clean-up is possible in a shorter time. The levels of chlorine required in water during the various stages of seafood processing is given in the annexure. 2.

IV. The biological examination of water

The biological examination of water is concerned with certain types of bacteria, algae, fungi, moulds and certain types of worms, insects, and crustaceans.

Unpolluted water from underground sources is free from biological contamination. But when pollution occurs, extensive growths of filamentous bacteria can be found. Surface waters such as rivers and lakes may contain very large number of plant and animal forms.

Ideally, a treated water for public supply should not contain any forms of animal or vegetable life. But small numbers of diatoms and other algae are common in public supplies derived from surface sources. A wide variety of animal forms has been found at various times from water mains. Most of these animal forms rarely pass through consumer taps. There are no definite standards for biological quality of potable waters. But the numbers of organisms are kept to a minimum. Further treatment of some waters is necessary for certain food industries such as soft drinks.

The amounts of microscopic organisms bear a direct relationship to the

various forms of nitrogen determined in the chemical analysis. As these growths increase free ammonia and nitrate decrease and albuminoid ammonia increases and as the growths decrease the reverse relationship holds.

Large numbers of organisms cause an unsightly turbidity to water. Even relatively small quantities frequently cause complaint because of scum produced when bath tubs are filled with hot water or of stain left upon the sides of the white porcelain. If unfiltered water is filled in swimming pools, the water will sometimes be unsightly.

Growth of living matter in water produces taste and odour. When odours described as aromatic are observed, diatoms or protozoa are to be blamed. Grassy odour may be due to cyanophyceae and fishy odour is caused by chlorophyceae and a few protozoa.

Outbreaks of human gastroenteritis have never been positively traced to algae. But a large number of cases of human algal intoxications such as gastrointestinal disorders, respiratory disorders, dermatological disorders have been reported.

Standards

Most of the uses of water in food industry necessitate certain standards of quality. In many cases, water of the standard of public supplies is quite satisfactory. But for certain industries water of a more specialised nature is required than that of some public water supplies.

1. Physical and chemical requirements

A comparison of the standards for drinking water of W. H. O, U. S. public

health services, Indian Council of medical research is given in the annexure 3. Indian Standards for water for processed food industry and for ice manufacture are given in the annexure 4.

2. Tolerances for radio-activity

Tolerances for radio-activity in 'Indian Standard Quality Tolerances for Water for Processed Food Industry' and in 'Indian Standard Quality Tolerances for water for Ice Manufacture' are the same. They are:

Characteristic	Tolerance
1. Alpha emitters, /uc/ml, Max.	10-9
2. Beta emitters, /uc/ml, Max.	10-8

2. Bacteriological standards

Reports on Public Health and Medical subjects No. 71 states that with chlorinated supplies, [coliform bacteria should be absent from 100 m. of water leaving the treatment works]. The same report recommends the following standard for water collected in the distribution system.

1. Throughout any year 95 per cent of samples and any two consecutive samples should not contain coliform organisms.

2. No sample should contain more than 10 coliform organisms or 2 E. coli per 100 ml.

3. Any sample should not contain 1 or 2 E. coli per 100 ml in conjunction with a total coliform count of 3 or more per 100 ml.

Standard for drinking water (untreated water) of Indian Council of Medical Research recommended the following requirements:

1. None of the samples should show

a MPN of coliform bacteria in excess of 10 per 100 ml.

2. If E. coli 1 is absent, a MPN of 20 per 100 ml may be permitted occasionally.

3. Treatment of the water supply should be considered, if the MPN of coliform bacteria per 100 ml is consistently 20 or more.

Indian Standards for water for processed food industry and for ice manufacture are given in the annexure 5.

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ANNEXURE 1

Characteristics of water	Hardness in ppm expressed as CaCO ₃
Soft water	0-50
Moderately soft water	50-100
Slightly hard	100-150
Moderately hard water	150-250
Hard water	250-350
Very hard water	350 and above.

ANNEXURE 2

Recommended level of available chlorine
in water used for seafood processing

Stage of processing	Recommended level of available chlorine in ppm.
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1. Factory sanitation:

The water used in the processing plant	5 ppm.
For ice manufacture	5 ppm.
For washing contaminated ice before using with the fish	5-10 ppm.
For washing the fish processing factories and primary processing centres after applying a suitable detergent in order to remove slime	10 ppm.
To disinfect these factories and centres	100 ppm.
To disinfect floor surfaces, gutters etc.	500-800 ppm.
For final washing	10 ppm.
To disinfect boat, decks, fish holds, wooden boxes etc.	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 into contact with seafood	100 ppm.

To disinfect workers washed hands 200 ppm.

2. Cooked frozen prawns

For cooling cooked material	10 ppm.
For dipping the material before packing ⁴	20 ppm.
For glazing	10 ppm.
For reglazing	50 ppm.

3. Canned seafood

For cooling processed cans 3 ppm.

4. Frozen frog legs

For washing the live frogs	200 ppm.
In 5% common salt solution used for keeping the severed legs for proper bleeding	200 ppm.
For washing the frog legs before storing in ice for transportation to the freezing plant	200 ppm.
In 5% common salt solution used for dipping the frog legs before skinning and trimming	500 ppm.
For washing each pair of leg after skinning and trimming	200 ppm.
For dipping the washed legs ⁵	200 ppm.
For washing these legs in order to remove the excessive smell of chlorine	5 ppm.

For dipping the polythene paper prior to wrapping individually 200 ppm.

1. Contact time is 4 minutes
2. Contact time is 4-5 minutes
3. Immersion time is 4-5 minutes
4. Dipping time is 10 minutes.
5. Contact time is 10 minutes.

ANNEXURE 3

Standards for drinking water

Test	W. H. O.		U. S. P. H. S.	I. C. M. R.	
	Max. acceptable concentration*	Max. allowable concentration*		Permissive	Excessive
1	2	3	4	5	6
Colour (Hazen or platinum-cobalt scale units)	5	50	Not exceeding 15	5	25
Turbidity units	5	25	Not exceeding 3	5	25
Odour	Unobjectionable	—	Not exceeding threshold odour number of 3 units	No disagreeable odour	—
Taste	Unobjectionable	—	—	No disagreeable taste	—
Iron (Fe)	0.3 mg/1	1.0 mg/1	Not exceeding 0.3 mg/1	0.3 mg/1	1.0 mg/1
Manganese (Mn)	0.1 mg/1	0.5 mg/1	Not exceeding 0.05 mg/1	0.1 mg/1	0.5 mg/1
Copper (Cu)	1.0 mg/1	1.5 mg/1	Not exceeding 1.0 mg/1	1.0 mg/1	3.0 mg/1
Zinc (Zn)	5.0 mg/1	15 mg/1	Not exceeding 5.0 mg/1	5.0 mg/1	15 mg/1
Total hardness (as CaCO ₃)	—	—	—	300 mg/1	600 mg/1
Calcium (Ca)	75 mg/1	200 mg/1	—	75 mg/1	150 mg/1
Magnesium (Mg)	50 mg/1	150 mg/1	—	50 mg/1	150 mg/1
Sulphate (SO ₄)	200 mg/1	400 mg/1	Not exceeding 250 mg/1	200 mg/1	400 mg/1
Chloride (Cl)	200 mg/1	600 mg/1	Not exceeding 250 mg/1	250 mg/1	1000 mg/1

	1	2	3	4	5	6
Phenols	1.001 mg/1	0.002 mg/1	0.002 mg/1	Not exceeding 0.001 mg/1	0.001 mg/1	0.002 mg/1
pH range	7.0—8.5	Less than 6.5 or greater than 9.2	Less than 6.5 or greater than 9.2	—	7.0—8.5	Less than 6.5 or greater than 9.2
Alkyl benzene sulphonates	0.5 mg/1	1.0 mg/1	1.0 mg/1	Not exceeding 0.5 mg/1	—	—
Carbon chloroform extract	0.2 mg/1	0.5 mg/1	0.5 mg/1	Not exceeding 0.2 mg/1	—	—
Nitrate (NO ₃)	—	45 mg/1	45 mg/1	Not exceeding 45 mg/1	20 mg/1	50 mg/1
Fluoride (F)	1.0 mg/1	1.5 mg/1	1.5 mg/1	1.7 mg/1 (at average max. daily air temperature of 50-54°F) down to 0.8 mg/1 (at temperature of 79.3 - 90.5)	1.0 mg/1	2.0 mg/1

Toxic substances

Arsenic (As)	0.05 mg/1	0.05 mg/1	0.05 mg/1
Barium (Ba)	1.0 mg/1	1.0 mg/1	1.0 mg/1
Cadmium (Cd)	0.01 mg/1	0.01 mg/1	0.01 mg/1
Chromium (Cr ⁶⁺)	0.05 mg/1	0.05 mg/1	0.05 mg/1
Cyanide (CN)	0.2 mg/1	0.01 mg/1	0.01 mg/1
Lead (Pb)	0.05 mg/1	0.05 mg/1	0.05 mg/1
Selenium (Se)	0.01 mg/1	0.01 mg/1	0.01 mg/1
Silver (Ag)	—	—	0.05 mg/1

* "Maximum acceptable concentration" applies and a water generally acceptable by consumers. "Maximum allowable concentration" values greater than those listed would markedly impair the potability of the water.

ANNEXURE 4

Standards for water for processed food industry and for ice manufacture

Characteristic	Tolerance	
	Food Industry	Ice manufacture
1. Colour (Hazen units), Max.	20	5
2. Turbidity (Units), Max.	10	5
3. Odour	None	None
4. pH	6.5 to 9.2	6.5 to 9.2
5. Total dissolved solids mg/1, Max.	1000	1000
6. Alkalinity (as CaCO ₃) mg/1, Max.	—	100
7. Total hardness (as CaCO ₃) mg/1, Max.	600	600
8. Sulphate (as SO ₄), mg/1, Max.	200	200
9. Fluoride (as F), mg/1, Max.	1.5	1.5
10. Chloride (as Cl), mg/1, Max.	250	250
11. Cyanide (as CN), mg/1, Max.	0.01	0.01
12. Selenium (as Se), mg/1, Max.	0.05	0.05
13. Iron (as Fe), mg/1, Max.	0.3	0.3
14. Magnesium (as Mg), mg/1, Max.	75.0	125
15. Manganese (as Mn), mg/1, Max.	0.2	0.2
16. Copper (as Cu), mg/1, Max.	1.0	1.0
17. Lead (as Pb), mg/1, Max.	0.1	0.1
18. Chromium (as Cr ⁺⁶), mg/1, Max.	0.05	0.05
19. Zinc (as Zn), mg/1, Max.	15.0	15.0
20. Arsenic (as As), mg/1, Max.	0.2	0.2
21. Nitrate (as N), mg/1, Max.	20	—
22. Phenolic substances (as C ₆ H ₅ OH), mg/1, Max.	0.001	0.001

Additional tolerances for specific operations for food industries

Characteristic	Tolerance for		
	Cooling	Washing, Flushing and general purposes	Processing
1. Total hardness (as CaCO ₃), mg/1, Max.	30	30	—
2. Iron (as Fe), mg/1, Max.	—	0.1	0.1
3. Manganese (as Mn), mg/1, Max.	—	0.1	0.1

Additional tolerances for canning

Operations	Characteristic	Tolerance
1. Cooker	a) Carbonate hardness	Zero
	b) Alkalinity (as CaCO ₃), mg/1, Max.	50
2. Cleansing	Total hardness (as CaCO ₃), mg/1, Max.	Preferably below 30
3. General	Iron (as Fe), mg/1, Max.	0.2

ANNEXURE 5

Bacteriological tolerances

Characteristic	Tolerance	
	Food Industry	Ice manufacture
1. Coliform bacteria, MPN index per 100 ml	Less than 1	Less than 1
2. Standard plate count, per ml, Max.	50	100
3. Proteolytic and lipolytic organisms, combined count per ml, Max.	5	—
4. Slime — forming organisms (for cooling water only)	Absent	—