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12 PRACTICAL
1.1 INTRODUCTION

Human beings, plants, animals, and all other forms of life need water in one or more ways and can’t survive without it. Water covers about 71% parts of earth’s total surface area. Although water is plentiful on earth, but 97% of total water available is too saline to drink and also not useful for agriculture and industrial purposes. The world’s total supply of fresh water is only 2.5% of the total amount and the rest being in the form of oceans. Water is one of the most wonderful creations of nature and is not only essential for plants and animals for sustaining life but is also equally important for agricultural, industrial, and other purposes. Thus, water available for drinking and other useful purposes is limited in amount. For drinking and industrial purposes, we prefer water that is free from all undesirable dissolved impurities.

1.2 COMMON IMPURITIES IN WATER

Water, when comes into contact with any substances becomes contaminated. Thus, it has been termed as Universal Solvent. Although, the solvency power of water is beneficial to mankind as juices and other drinking beverages, but it poses a major threat to industrial equipment, causing corrosion and scale formation.

Impurities in water can be physical (suspended impurities, colloidal impurities), chemical (dissolved gases, salts) or microscopic (microorganisms). Water impurities include dissolved and suspended solids. For example, a solution of calcium bicarbonate is clear as calcium and bicarbonate ions are atomic sized ions which are not large enough to reflect light (dissolved impurities), whereas, sea water has very high concentration of soluble sodium chloride, suspended sand and silt, collectively makes it slightly cloudy (suspended impurities). Some soluble minerals impart a color to the water when dissolved to prepare solution such as copper salt forms intense blue colored clear solution.

The impurities contained in water can be classified as follows:
1000 ml of the water sample = \( \frac{X \times V_1}{V_1 \times Z} \times 1000 \) mg of CaCO₃

Hence,

permanent hardness of the water = \( \frac{X \times V_1}{V_1 \times Z} \times 1000 \) mg of CaCO₃

For the temporary hardness of the water:

Temporary hardness = Total hardness – permanent hardness

### 1.5 PROBLEMS OF HARD WATER

Hard water possesses threats for both domestic and industrial use. The problems created by hard water in domestic and industrial purpose is as follows:

#### 1.5.1 In Domestic Use

Hard water is harmful for domestic use as:

(a) Hard water is harmful for drinking purposes, due to deposition of calcium in the bone joints and the possibility of forming calcium oxalate crystals in urinary tracts.

(b) When it is directly fed in boilers for steam generation, causes many problems including scale and sludge formation, corrosion, priming and foaming and caustic embrittlement.

(c) It does not form lather with soaps or detergents. The soap (sodium stearate) gives lather with water, when all calcium and magnesium salt present in water are precipitated. The reaction of lather formation is:

\[
\text{C}_{17}\text{H}_{35}\text{COONa} + \text{H}_2\text{O} \rightleftharpoons \text{C}_{17}\text{H}_{35}\text{COOH} + \text{NaOH}
\]

\[
\text{C}_{17}\text{H}_{35}\text{COOH} + \text{C}_{17}\text{H}_{35}\text{COONa} \rightarrow \text{Lather}
\]

This causes wastage as a lot of soap is being used.

(d) Due to the presence of dissolved hardness producing salts, the boiling point of water is increased. Consequently, more fuel and time are required for cooking.

#### 1.5.2 In Industry

Water has a variety of applications in almost all the industries. Each
industry requires water with a definite specification. The specifications of water required for some important industries are as follows:

(a) Paper and pulp industries: In paper and pulp industries water should be free from iron and manganese salts and suspended matter. These impurities decrease the brightness, affect colors and interfere with texture and uniformity. Suspended silica particles in water produce cracks in paper.

(b) Sugar industry: Hard water causes difficulties in the crystallization of sugar from molasses. It also causes the formation of precipitates, which accumulate in the refined sugar.

(c) Textile and dyeing industries: Hard water precipitates basic dyes and decreases the solubility of acidic dyes, whereas iron and manganese salts produce colored spots on fabrics.

(d) Starch industry: The water required for starch industry should be as soft and mineral free as possible. Hard water causes precipitation of salts which accumulate in the starch. Iron and manganese salts provide yellowish colouration to the starch, which is not desirable.

(e) Aluminium industry: Water is used for washing the hydrate in aluminium industry. Thus the water should be of high quality. Any impurity introduced in the hydrate wash tends to accumulate in NaOH solution and impair its function.

(f) Carbonated beverage industries: The industries manufacturing carbonated beverages require water, which should be free from organic matter, turbidity, color, taste, odour, micro-organisms, iron and manganese salts. It should be of uniformly low alkalinity.

(g) Laundries: The water used in laundries should be soft. The hard water increase the consumption of soap. Water should also be free from iron and manganese salts, which cause stains on the materials being washed. Water should not contain high bicarbonate alkalinity.

************
EXAMPLE 1.4

20 ml of 0.1 Na₂CO₃ solution was added to 100 ml of a sample of hard water. The filtrate from the solution required 30 ml of 0.05 N H₂SO₄ for complete neutralization. Calculate the hardness of the water sample.

**SOLUTION :**

The filtrate = 30 ml of 0.05 H₂SO₄

\[
\frac{30 \times 0.05}{0.1} \text{ ml of 0.1 N H₂SO₄}
\]

15 ml of 0.1 N Na₂CO₃ solution consumed in precipitating hardness in 100 ml of hard water = 20 - 15 = 5 ml. So that

100 ml of water sample = 5 ml of 0.1 N Na₂CO₃ solution

or \[100 \times \text{Hardness} = 5 \times 0.1\]

or \[\text{Hardness} = \frac{0.1}{2} = 0.005\]

Strength of hardness as CaCO₃ equivalents

\[
= 0.005 \times 50 \text{ gm per liter}
\]

\[
= \frac{0.005 \times 50 \times 10^6}{1000} \text{ mg/L} = 250 \text{ ppm}
\]

EXAMPLE 1.5

100 ml of tap water was titrated with N/50 HCl with methyl orange as an indicator. If 30 ml of HCl were required, calculate the hardness as parts of CaCO₃ per 100000 parts of water. The hardness is temporary.

**SOLUTION :**

For the temporary hardness, the chemical reaction is

\[
\text{Ca(HCO}_3\text{)} + 2\text{HCl} \rightarrow \text{CaCl}_2 + 2\text{CO}_2 + 2\text{H}_2\text{O}
\]

Thus 2 equivalents of HCl \(\equiv\) Ca(HCO₃)₂ \(\equiv\) CaCO₃ (since 100 parts)

\[
\text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{Ca(HCO}_3\text{)}_2
\]

Therefore, 1 equivalent of HCl = 50 gm CaCO₃

Now \[100 \text{ ml of tap water} = 30 \text{ ml of N/50 HCl}\]

\[
= \frac{30}{50} \text{ ml of N HCl}
\]

\[
= \frac{30 \times 0.05}{50} = 0.03 \text{ gm CaCO}_3
\]
2

MUNICIPAL WATER SUPPLY

2.1 INTRODUCTION

The water from the surface sources may have some characteristics which are unsuitable for human consumption, industrial use and commercial use. Water free from these characteristics is known as municipal water or potable water. The whole process of making water free from impurities and supply it to the consumer as shown in Fig. 2.1, is known as municipal water supply.

2.1.1 Drinking Water or Municipal Water

Water is a vital and essential requirement of all the living creatures. A large amount of water is consumed for drinking, washing and various other purposes. The water with impurities is not suitable for the domestic uses. The water, which is safe for drinking, is called the potable water. The natural water, obtained from rivers, underground wells and canals does not have the characteristic of the potable water. Hence, it is necessary to do some treatment of these types of water to make them potable.
2.3 PURIFICATION OF WATER

The type of treatment given to water largely depends upon the quality of raw water and also upon the specified standards. Usually, water treatment for municipal supply or domestic use consists of the following stages:

Table 2.2 Different Processes Used for Treatment of Municipal Water.

<table>
<thead>
<tr>
<th>Process used for Treatment</th>
<th>Impurities removed from water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening</td>
<td>Floating matter like leaves, twigs, etc.</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>Suspended matter like sand, clay, etc.</td>
</tr>
<tr>
<td>Coagulation and Flocculation</td>
<td>Fine suspended inorganic matter</td>
</tr>
<tr>
<td>Filtration</td>
<td>Colloidal impurities and large sized microorganisms.</td>
</tr>
<tr>
<td>Sterilization and Disinfection</td>
<td>Bacteria and microorganisms.</td>
</tr>
</tbody>
</table>

2.3.1 Screening

In screening treatment the raw water obtained from rivers, reservoirs and lakes is passed through steel screens, having large number of holes. Solid floating materials such as dead fish and animals, bits of wood, leaf, weeds and others debris presents in water are simply retained by the screen.

2.3.2 Sedimentation

Removing of suspended clay and other colloidal matter present in water by the process of setting is known as sedimentation. There are two types of sedimentation, plain sedimentation and sedimentation by coagulation.

1. Plain sedimentation

In plain sedimentation, the screened water is lead into a large tank and simply allowed to stand undisturbed for several hours. Heavy and suspended particles settle down at bottom by gravitational force. The time required for plain sedimentation largely depends upon the weight, size and shape of the particles.

The following are the main disadvantages of plain sedimentation process:
   (i) Longer detention period is required.
   (ii) Removal of lower density particles cannot be possible.
Table 2.3. Compares the properties of Slow Sand Filter and Rapid Sand Filter.

<table>
<thead>
<tr>
<th>No.</th>
<th>Particulars</th>
<th>Slow Sand Filter</th>
<th>Rapid Sand Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Area</td>
<td>Requires larger area for installation</td>
<td>Required small area for installation</td>
</tr>
<tr>
<td>2.</td>
<td>Base material</td>
<td>Gravel size varies from 3-65 mm.</td>
<td>Gravel size varies from 3-40 mm.</td>
</tr>
<tr>
<td>3.</td>
<td>Method of cleaning</td>
<td>Scraping top layer of sand to a thickness of about 25 mm</td>
<td>Back washing by water and compressed air.</td>
</tr>
<tr>
<td>4.</td>
<td>Quality of sand</td>
<td>Fine sand, effective size 0.20-0.35 mm, uniformity coefficient 2 to 2.75</td>
<td>Coarse sand, effective size 0.35-0.65 mm, uniformity coefficient 1.20 to 1.80</td>
</tr>
<tr>
<td>5.</td>
<td>Supervision</td>
<td>Skilled supervision not required.</td>
<td>Skilled supervision required</td>
</tr>
<tr>
<td>6.</td>
<td>Period of cleaning</td>
<td>1 to 3 months</td>
<td>2 to 3 days</td>
</tr>
<tr>
<td>7.</td>
<td>Economy</td>
<td>It is not economical.</td>
<td>It is economical.</td>
</tr>
<tr>
<td>8.</td>
<td>Rate of filtration</td>
<td>100 to 200 lits per hr per m² of surface area of filter.</td>
<td>3000 to 6000 lits per hr per m² of surface area of filter.</td>
</tr>
<tr>
<td>10.</td>
<td>Suitability</td>
<td>It is suitable for towns.</td>
<td>It is suitable for large cities.</td>
</tr>
</tbody>
</table>

2.3.5 Sterilization and Disinfection

Contaminated water is main cause for the spreading of many diseases like cholera, typhoid, etc. Therefore, to insure water, free from harmful bacteria and viruses, drinking water is treated with certain disinfectants. The chemical which are used to destroy the bacteria and viruses are called the disinfectants and this process of destruction of bacteria and viruses (harmful microorganism) is called the disinfection. Unlike disinfection,
introduced during the removal of permanent magnesium hardness, Fe$^{2+}$, Al$^{3+}$, HCl and H$_2$SO$_4$ by lime. Thus, for the calculation of the amounts of lime and soda required for the treatment of a given sample of water, it would be easy to convert the amounts of all the substances present in the sample in terms of CaCO$_3$ equivalent. As we have already seen, CaCO$_3$ equivalent is given by

$$\text{CaCO}_3 \text{ equivalent} = \frac{W \times 50}{W_{\text{Eqvi.}}}$$

where,

$W$ = weight of the impurity.

$W_{\text{Eqvi.}}$ = equivalent weight of the impurity.

The lime and soda requirements can be calculated as follows.

**Lime Requirement**

100 parts by weight of CaCO$_3$ are equivalent to 74 parts by weight of Ca(OH)$_2$. Hence, if the amounts of impurities are expressed in terms of their CaCO$_3$ equivalents, the amount of lime required to soften a given sample of water is given by

$$\text{Lime required for softening} = \frac{74}{100} \times \left[ T \text{emporary calcium hardness} + 2(T \text{emporary magnesium hardness}) + \text{Permanent magnesium hardness} + CO_2 + HCl + H_2SO_4 + \text{salts of Fe}^{2+}, \text{Al}^{3+} \text{etc.} + HCO_3^- - NaAlO_2; \right] \times \text{Volume of Water}$$

**Soda Requirement**

As stated before soda removes both permanent calcium hardness and the permanent calcium hardness introduced during the removal of permanent magnesium hardness, Fe$^{2+}$, Al$^{3+}$, HCl and H$_2$SO$_4$ by lime. Hence, the permanent calcium hardness introduced during the removal of the above-mentioned impurities by lime must also considered while calculating the soda requirement.

100 parts by weight of CaCO$_3$ are equivalent to 106 parts by weight of Na$_2$CO$_3$.

Thus, if the amounts of impurities are expressed in terms of their CaCO$_3$ equivalents, the amount of soda required for the removal of permanent calcium hardness already present and the permanent calcium hardness introduced during the removal of permanent magnesium hardness,
3.3.3 Demineralization or Deionization Process

Demineralization is the process of complete removal of all the hardness producing ions present in water. The water produced from this process is also known as deionised water.

The two important demineralization processes are explained as follows:

1. Ion-exchange Process

Ion-exchange process is defined as the complete separation of the dissolved ions present in water by the help of some complex organic compounds (resins). These resins act as ion-exchangers and remove all minerals from the hard water. They remove all cations (negatively charged ions) and anions (positively charged ions), except H⁺ and OH⁻ ions from hard water and make it completely free from ions, so it is called demineralization.

The resins are very complex organic compounds capable of exchanging all the ions present in hard water. They are of following two types:

(i) Cation exchange resins: Mainly carboxylated or sulphonated styrene-divinylbenzene copolymers are known as cation exchange resins. These resins possess acidic groups such as −COOH or −SO₃H groups and may be represented as R−H⁺. The structure of a cation exchange resin containing −SO₃H groups can be...
Conversion into CaCO$_3$ equivalents is shown below in table:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Constituent</th>
<th>Amount ppm</th>
<th>Multiplication factor</th>
<th>CaCO$_3$ equivalent (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ca$^{+2}$</td>
<td>40</td>
<td>$\frac{100}{40}$</td>
<td>$40 \times \frac{100}{40} = 100$</td>
</tr>
<tr>
<td>2.</td>
<td>Mg$^{+2}$</td>
<td>48</td>
<td>$\frac{100}{24}$</td>
<td>$48 \times \frac{100}{24} = 200$</td>
</tr>
<tr>
<td>3.</td>
<td>CO$_2$</td>
<td>22</td>
<td>$\frac{100}{44}$</td>
<td>$22 \times \frac{100}{44} = 50$</td>
</tr>
<tr>
<td>4.</td>
<td>HCO$_3^-$</td>
<td>122</td>
<td>$\frac{100}{122}$</td>
<td>$122 \times \frac{100}{122} = 100$</td>
</tr>
<tr>
<td>5.</td>
<td>K$^+$</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lime required for Mg$^{+2}$, CO$_2$, and HCO$_3^-$ as CaCO$_3$ equivalent

$$\text{Lime} = \frac{74}{100} \times [\text{Mg}^{+2} \times \text{CO}_2 \times \text{HCO}_3^-],$$

$$= \frac{74}{100} \times [200 + 50 + 100]$$

$$= \frac{74}{100} \times 350 = 259 \text{ ppm or mg/L}$$

Lime (80% pure) required for million litres of water

$$= \text{lime required} \times \frac{100}{80} \times \text{Volume of water}$$

$$= 259 \times \frac{100}{80} \times 10^6 \text{ mg}$$

$$= 323750000 \text{ gm} = 323.75 \text{ kg}$$

Soda required for Ca$^{+2}$, Mg$^{+2}$, and HCO$_3^-$

$$\text{Soda} = \frac{106}{100} \times [\text{Ca}^{+2} \times \text{Mg}^{+2} \times \text{HCO}_3^-],$$

$$= \frac{106}{100} \times [100 + 200 - 100]$$

$$= \frac{106}{100} \times 200 = 212 \text{ ppm or mg/L}$$

Soda required (90%) for 1 million liters of water

$$= \text{Soda required} \times \frac{100}{90} \times \text{Volume of water}$$

$$= 212 \times \frac{100}{90} \times 10^6 \text{ mg}$$

$$= 235555555 \text{ mg} = 235.5 \text{ kg}$$
EXAMPLE 3.8 1998, 2000

Calculate the quantities of lime and soda needed for softening 2000 litres of hard water which analyzed as follows:

<table>
<thead>
<tr>
<th>Analysis of raw water</th>
<th>Analysis of treated water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca(^{+2}) – 160 ppm</td>
<td>CO(_3^{−2}) – 30 ppm</td>
</tr>
<tr>
<td>Mg(^{+2}) – 72 ppm</td>
<td>OH(^{−}) – 17 ppm</td>
</tr>
<tr>
<td>HCO(_3^{−}) – 732 ppm</td>
<td></td>
</tr>
<tr>
<td>Dissolved CO(_2) – 44 ppm</td>
<td></td>
</tr>
<tr>
<td>HCl – 7.3 ppm</td>
<td></td>
</tr>
</tbody>
</table>

SOLUTION:

Conversion to equivalent of CaCO\(_3\) is shown in table:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Constituent (ppm)</th>
<th>Amount (ppm)</th>
<th>Multiplication (ppm)</th>
<th>CaCO(_3) Equivalent (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ca(^{+2})</td>
<td>160</td>
<td>(\frac{100}{40})</td>
<td>(160 \times \frac{100}{40} = 400)</td>
</tr>
<tr>
<td>2</td>
<td>Mg(^{+2})</td>
<td>72</td>
<td>(\frac{100}{24})</td>
<td>(72 \times \frac{100}{24} = 300)</td>
</tr>
<tr>
<td>3</td>
<td>HCO(_3^{−})</td>
<td>732</td>
<td>(\frac{100}{122})</td>
<td>(732 \times \frac{100}{122} = 600)</td>
</tr>
<tr>
<td>4</td>
<td>CO(_2)</td>
<td>44</td>
<td>(\frac{100}{44})</td>
<td>(44 \times \frac{100}{44} = 100)</td>
</tr>
<tr>
<td>5</td>
<td>HCl</td>
<td>7.3</td>
<td>(\frac{100}{73})</td>
<td>(7.3 \times \frac{100}{73} = 10)</td>
</tr>
<tr>
<td>6</td>
<td>OH(^{−})</td>
<td>17</td>
<td>(\frac{100}{17})</td>
<td>(17 \times \frac{100}{17} = 100)</td>
</tr>
<tr>
<td>7</td>
<td>CO(_3^{−2})</td>
<td>30</td>
<td>(\frac{100}{60})</td>
<td>(30 \times \frac{100}{60} = 50)</td>
</tr>
</tbody>
</table>

Amount of lime required for softening raw water is

\[
\frac{74}{100}[Mg^{+2} + HCO_3^- + CO_2 + HCl] \text{ as CaCO}_3 \text{ eq.}
\]
\[ 169.6 \times \left( \frac{100}{90} \right) \times 20000 \text{ mg} \]
\[ = 3.77 \times 10^6 \text{ mg} = 3.77 \text{ kg} \]

Hence, cost of softening is
\[ = 4.05 \times \left( \frac{75}{100} \right) \text{ Rs.} + 3.77 \times \left( \frac{2480}{100} \right) \text{ Rs.} \]
\[ = 3.04 + 93.50 = \text{ Rs.} 96.54 \]

**EXAMPLE 3.13**

Calculate the amount of lime and soda required for softening 50000 litres of hard water containing: MgCO ppm144, CaCO ppm253, MgCl ppm952, CaCl ppm1112, Fe O ppm2523, Na SO ppm15.

**SOLUTION :**

Conversion into CaCO3 equivalents are shown in table:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Constituent</th>
<th>Amount (ppm)</th>
<th>Multiplication factor</th>
<th>CaCO3 Equivalent (ppm or mg/ L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MgCO3</td>
<td>144</td>
<td>( \frac{100}{84} )</td>
<td>( 144 \times \frac{100}{84} = 171.4 )</td>
</tr>
<tr>
<td>2</td>
<td>CaCO3</td>
<td>25</td>
<td>( \frac{100}{100} )</td>
<td>( 25 \times \frac{100}{100} = 25.0 )</td>
</tr>
<tr>
<td>3</td>
<td>MgCl2</td>
<td>95</td>
<td>( \frac{100}{95} )</td>
<td>( 95 \times \frac{100}{95} = 100.0 )</td>
</tr>
<tr>
<td>4</td>
<td>CaCl2</td>
<td>111</td>
<td>( \frac{100}{111} )</td>
<td>( 111 \times \frac{100}{111} = 100.0 )</td>
</tr>
</tbody>
</table>

Substances FeO and Na2SO4 do not impart any hardness and therefore, these do not consume any lime or soda.

Lime requirement
\[ = \frac{74}{100} [2 \text{MgCO} + \text{CaCO} + \text{MgCl}] \text{ as CaCO3 eq.} \times \text{ Vol. of water} \]
\[ = \frac{74}{100} [2 \times 171.4 + 25.0 + 100.0] \text{ mg/ L} \times 50000 \text{ L} \]
\[ = \frac{74}{100} (467.8) \times 50000 \text{ mg} \]
\[ = 17308600 \text{ mg} = 17.31 \text{ kg} \]
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>100</th>
<th>100</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>MgSO₄</td>
<td>30.0</td>
<td>120</td>
<td>30.0</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>CaSO₄</td>
<td>34.0</td>
<td>136</td>
<td>34.0</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>CaCl₂</td>
<td>27.75</td>
<td>111</td>
<td>27.75</td>
<td>25</td>
</tr>
</tbody>
</table>

**NaCl** do not contribute any hardness.

Temporary hardness = \[\text{Ca}(\text{HCO}_3)₂ + \text{Mg}(\text{HCO}_3)_2\] as CaCO₃ eq.

\[= 25 + 25 = 50 \text{ ppm}\]

Permanent hardness = \[\text{MgSO}_4 + \text{CaSO}_4 + \text{CaCl}_2\] as CaCO₃ eq.

\[= 25 + 25 + 25 = 75 \text{ ppm}\]

Lime is required for Ca(HCO₃)₂, Mg(HCO₃)₂ and MgSO₄.

Hence 84% pure lime is required for treating 20,000 liters of water is

\[= \frac{74}{100} \times \frac{\text{Purity}}{\text{Volume of water}}\]

\[= \frac{74}{100} \times \frac{100}{84} \times 20000\]

\[= 1761904.76 \text{ mg} = 1.7619 \text{ kg}\]

************
concentration of solute or suspended matter between the surface film and the bulk of the liquid. Foaming is due to the presence of oil or grease which generally reduces the surface tension of water in boiler.

The substances which increase the viscosity of the surface film also increase foam forming tendency.

Caus es of Priming and Foaming

(i) The presence of large quantities of alkali sulphate and chloride in water.
(ii) Sudden boiling.
(iii) Sudden increase in steam production rate.
(iv) Improper boiler design.
(v) The high steam velocities.
(vi) Very high water level in the boiler.

Disadvantages of Priming and Foaming

Priming and foaming are often used synonymously. These are highly objectionable because the droplets of water carry away with them some suspended and dissolved impurities present in the boiler water. These droplets and impurities lead to the following disadvantages:

(i) A part of the dried salts may be carried along with the steam farther and deposit on the engine valves thereby decreasing their life.
(ii) These deposite reduce their efficiency by hindering the flow of steam.
(iii) Presence of water droplets in the steam may lead to corrosion in the steam-inlet ends of super-heaters.
(iv) Height of the water column cannot be judged properly due to foaming thereby making the maintenance of the boiler pressure difficult.

Prevention of Priming

Priming can be avoided by:

(i) Keeping the water level lower.
(ii) Reducing steam velocities also decreases the moisture content of steam because of greater chances of condensing available for the drop.
(iii) Efficient softening and filtration of boiler feed waters so as to minimize the dissolved and suspended impurities.
(iv) Good boiler design fitted with mechanical steam purifiers.
(v) Avoiding rapid change in steaming rate.
4. BIOSPHERE

This is the region of the earth where life exists and includes a global region extending from about 10,000 m below sea-level to 6,000 m above sea-level. Thus the biosphere covers the entire kingdom of living organism and their interactions with the other segments of the environment, namely the lithosphere, the hydrosphere and the atmosphere.

5.3 ENVIRONMENT AS SCIENCE AND EDUCATION

Environmental science may be defined as the systematic study of the effect of humans on the environment. Using the term “systematic” indicates that it is a science.

The use of the term Environmental Studies may simply be a single subject, but its essence is its multidisciplinary nature. As a relatively new field, it has evolved from the integrated use of many disciplines and includes some of the most important topics of modern civilization as well as some of the oldest philosophical concerns of the human beings. Environmental studies encompasses many other fields such as given in table 5.1.

Table 5.1. Different Fields of Environmental Study.

| Biology | • Physics        | • Sociology        |
|         | • Chemistry      | • Political Science|
|         | • Ecology        | • Philosophy       |
|         | • Paleontology   | • Arts             |
|         | • Religion       | • Literature       |
|         | • Geology        |                   |
|         | • Economics      |                   |
|         | • History        |                   |
|         | • Law            |                   |

It is therefore a complex topic. As with any of the sciences, Environmental Scientists don’t know about all of these, areas, but specialize. For example, it may be someone who studies the effects of pollution on groundwater, which would include chemistry, geology, and biology. One may instead be interested in the effects of environmental regulations on a segment of the economy, in this case be might be called and Environmental Economist.

Environmental education is an integral process, which deals with man’s interrelationship with his natural and man made surroundings, including the relation of population growth, pollution, resource allocation and depletion, conservation, technology and urban rural planning to the total human environment. Environmental education is a study of the factors influencing ecosystems, mental and physical health, living and
(vi) Relationship of the proposed activity to the existing land use plans i.e. conformity or conflict with other land use plans and policies (when in conflict—extent of recommendation and reasons for proceeding with action).

(vii) Relationship between the local short term uses and long term productivity of the resources involved.

(viii) Identifying the measures to minimise the adverse effects.

(ix) Incorporating the modification in the proposed project.

After it has been written, the EIS is presented to the public to make the role of public participation more effective in developmental planning process.

4. Review of the EIS

Finally the EIS, written in a clear and comprehensive manner is presented to the public, competent authorities and independent experts. It is reviewed carefully before any decision is taken in favour or against passing the propose project.

In order to maintain a safe and healthy environment and to upgrade the standard of living by taking advantages of new technological developments without exploiting the environment, responsible and concerned public participation is important.

The proposed project is then made available for public inspection by publicity through the press for a period of at least one month in addition with discussion sessions of the government agency, the proponent and the public. This provides the further information and submission of comments from the public and competent authorities.

After the final review of beneficial and adverse environmental impacts and cost benefit analysis, ultimately a decision is made to either approve or reject the project or approve the most acceptable alternative in actual or modified form. Cost effectiveness of EIA can be improved by:

(i) Reducing unnecessary assessment and monitoring by better screening.

(ii) Making use of available data and experience.

(iii) Assigning responsibilities to the members of the analysis team, thereby avoiding duplication or overlapping of duties and activities.

(iv) Simplifying administrative procedures.

5.12.3 Role of EIA in Sustainable Development

Sustainable development is closely linked to the carrying capacity of an ecosystem as the latter determines the limits to economic development.
purposes because sunlight falling on any black surface is readily absorbed and converted to heat in the desired temperature range. Temperature of about 20°–22°C are used for space heating and 50°–60°C are used for hot water. Therefore, complex collection or conversion equipment is not required when solar energy is to be used for obtaining low-temperature heat. A simple flat-plate collector is sufficient.

Flat-plate collectors basically consists of a black surface covered by a clear plastic or glass “window” as shown in Fig. 5.3. The black surface absorbs sunlight converts it to heat and the window prevents the heat from escaping out. Air can be heated by passing it between the window and the black surface whereas water heating can be done by passing it through tubes embedded in the surface. Thus, minimum cost is involved in collecting and converting solar energy to heat.

Figure 5.3

Solar heating system may be “Active” or “passive”. An active solar heating system uses either pumps or blowers to circulate the air or water.
Solar Furnaces

In solar furnace, high temperature is obtained by concentrating the solar radiations onto a specimen using a number of heliostats (turnable mirrors) arranged on a stopping surface. The solar furnace is used for studying the properties of ceramics at extremely high temperatures above the range measurable in laboratories with flames and electric currents. Heating can be accomplished without any contamination and temperature can be easily controlled by changing the position of the material in focus. This is especially useful for metallurgical and chemical operations. Various property measurements are possible on an open specimen.

An important future application of solar furnaces is in the production of nitric acid and fertilizers from air.

Solar Cooking

A simple solar cooker is the flat plate box type solar cooker. It consists of a well insulated metal or wooden box in which is blackened from the inner side. The solar radiations entering the box are of short wavelength. As higher wavelength radiations are unable to pass through the glass covers, the re-radiation from the blackened interior to outside the box through the two glass covers is minimized, thereby minimizing the heat loss.

The heat loss due to convection is minimized by making the box air tight. This is achieved by providing a rubber strip between the upper lid and the box for minimizing the heat loss due to conduction, the space between the blackened tray and outer cover of the box is filled with an insulating material like glasswool, saw-dust, paddy husk etc.

When placed in sunlight, the solar rays penetrate the glass covers and are absorbed by the blackened surface thereby resulting in an increase in temperature inside the box. Cooking pots blackened from outside are placed in the solar box. The uncooked food gets cooked with the heat energy produced due to increased temperature of the solar box. Collector area of such a solar cooker can be increased by providing a plane reflector mirror. When this reflector is adjusted to reflect the sun rays into the box, then a 15°C to 25°C rise in temperature is achieved inside the cooker box.

Solar Green Houses

A green house is a structure covered with transparent material (glass or plastic) that acts as a solar collector and utilizes solar radiant energy to grow plants. It has heating, cooling and ventilating devices for controlling the temperature inside the greenhouse.

Solar radiations can pass through the green house glazing but the thermal radiations emitted by the objects within the green house cannot.
that out flowing water continues to generate power. At present, tidal power plants are in operation in Russia, France and Nova Scotia.

For any tidal power project to be of practical use, a fluctuation of at least 6 meters is needed between the high tide and low tide. Such a situation exists only at about 15 locations in the world. The Bay of Fundy in North America is one of such locations and a large tidal power plants is being developed.

Tidal plants are accompanied by the adverse environmental effects because of the dams which may trap sediments, impede the migration of marine organisms, change water circulation and cause mixing of fresh water with salt water.

Ocean Thermal Energy Conversion (OTEC)

In oceans, a thermal gradient (temperature difference) of about 20°C exists between surface water heated by the sun and colder deep water. In tropical regions, the temperature of the surface layers of the ocean is as high at 26°C, whereas at a depth of 1,000 meters, the temperature is 5 to 6°C. This temperature difference can be harnessed to produce power. This concept is known as Ocean Thermal Energy Conversions (OTEC). An OTEC power plant can be built on a brage (i.e. sailing vessel) that could travel anywhere in the ocean. It uses the warm surface water to heat and vaporize a low boiling liquid such as ammonia. The increased pressure of the vaporized liquid would drive turbo generators. The ammonia vapour leaving the turbines would then be condensed by cold deep water which is about 100 m below the surface and is returned back to start the cycle again. The electrical power so generated could be used to produce hydrogen and shipped to the shore. Alternatively, an energy intensive industry can be located on factory ships that would anchor alongside the OTEC Plant. A few OTEC Plants have been tested.

In addition to electricity, an OTEC plant delivers cold sea water to the surface, which can be used to air-condition nearby buildings. The water from the deep ocean, which is rich in nutrients, can support agriculture and mariculture enterprises. An experimental station in Hawaii is exploring the possibilities for integrated power, water, air-conditioning and farming activities on the shore.

Further, the difference in salt concentration between the oceans and fresh water represents a large osmotic pressure which is equivalent to a 240 meter water head. A practical application of using this mixing energy is worth exploring.

Owing to the small temperature difference between the surface water and deep water, the conversion efficiency is as low as 2-3%. This
Table 5.3. Estimates of Potential Capacities from Renewable Energy Sources (in MWs)

<table>
<thead>
<tr>
<th>Source</th>
<th>Approximate Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass Energy</td>
<td>19500</td>
</tr>
<tr>
<td>Solar Energy</td>
<td>20000</td>
</tr>
<tr>
<td>Wind Energy</td>
<td>47000</td>
</tr>
<tr>
<td>Small Hydropower</td>
<td>15000</td>
</tr>
<tr>
<td>Ocean Energy</td>
<td>50000</td>
</tr>
</tbody>
</table>

Energy Production and Reserves

India is the third most coal producing country of the world. Coal production has grown considerably from 100 MT (million tonnes) in 1975-76 to 306 MT in 1998-1999. Only about 15% of the coal produced has coking properties and is used in the iron and steel industry. The bulk of the coal produced in inferior grade non-coking coal used to meet the demands of the power sector. This coal is of poor quality with a high ash content (40-50%) and low calorific value (1300-4200 Kcal/kg).

India is one of the least explored regions with an oil well density of 20 per 10000 sq km against a world's average of 100. Inspite of a significant growth, domestic production has not matched demand which tends to a constant growth in net imports as estimated at 39.81 MT of crude oil and 17.4 MT of petroleum products in 1998-99. The country’s self reliance in petroleum products has declined from 56% in 1990-91 to about 34% in 1998-99.

The share of hydro in the hydro-thermal capacity mix has changed significantly since the early 1970s. It was 43% in 1970-71 which has now come down to about 24%. India also has substantial reservoir of nuclear fuels with the world’s largest deposits of thorium, about 363 thousand tonnes and about 34 thousand tonnes of the Uranium ore.

Traditionally India has been deficient in power generation with compare to its demand. The following table 5.4, shows deficit and capacity additions during various plan periods.

In India with the high rate of growth in population and increasing development needs, the growth in the demand of primary energy has been accompanied by a shift to an increase in the share of commercial energy in the total energy demand. The domestic sources of commercial energy supply have not kept pace with growing requirements as may be seen from the following table 5.5.