CHAPTER --- V

Water Resource Pollution

5.0 Introduction:

Water resource quality is as important as the quantity. The suitability of water for domestic, agricultural and industrial uses is based on water inhibition physical, chemical and biological indices popularly known as water quality standards. Any water quality indices beyond its permissible limits considered to be unfit for use and termed polluted.

Water pollution maybe attributed to both natural and anthropogenic and both factors. However, in the current phase of development - urbanization, industrialization and irrigation are the major factors of water pollution. Therefore, anthropogenic factors predominate over natural factor (Plate 5.1).

Plate 5.1/A A View of Polluted River.
Plate 5.1(B) Anthropogenic Activity Source of Water Pollution.

5.1 Global Water Pollution Scenario

Water pollution is a global problem but it differs with levels of development in different countries. In general terms, water pollution has severe impacts on the usefulness the value of water resources. It leaves negative impacts on ecosystems, fisheries, food production, health and social development and economic activities are in respect of international relations these days, and water pollution can cause or aggravate tension and conflicts among water users and even between countries.

As regards water shortage, it is very often induced by pollution as many centers of population are located on riverbanks. And since polluted water is unsuitable for domestic, industrial or agricultural use, it represents a net loss of water resources. Water shortage in dry regions is often caused or aggravated by economic activities including agriculture that is not suited for the local conditions. As a rule, such activities are in turn heavily polluting.

“Filthy water cannot be washed” so goes with an African proverb. The major problems affecting water quality and aquatic ecosystems, as identified at the
Rio Earth Summit (1992) are untreated domestic sewage, uncontrolled industrial discharges, deforestation and poor agricultural practices that result in soil erosion and leaching of nutrients and pesticides.

Public awareness regarding the protection of the freshwater resources as well as monitoring of the ecological and human health effects have also been inadequate. Agenda 21, the plan of work adopted to conserve and protect the environment, called for the adoption of a catchment management approach and the “Polluter pays” principle as well as for immediate action on ecosystem restoration and monitoring, groundwater protection, treatment facilities for domestic sewage and industrial effluents and rational use of fertilizers and pesticides.

The United Nations’ Commission on Sustainable Development (CSD) during its 6th Session in 1998 had noted some improvements in water quality occurring in a number of river basins and groundwater aquifers where action had been taken since Rio but overall progress had not been sufficient to reduce general trends of deteriorating water quality and growing stress on freshwater ecosystems. The unsustainable trends that prevailed at the time of Rio and CSD 6th Session have not been reversed while global cooperation has proven to be especially difficult on the issue of freshwater access and protection. Pollution of freshwater still remains a major cause of global concern and a threat to aquatic ecosystems as recently stated in the Ministerial Declaration of the 2nd World Water Forum (2000).

Today, more than one billion people still lack access to clean drinking water, while approximately two and a half billion do not have adequate sanitation services. According to a survey conducted for the report Global Environment Outlook (2000), the most frequently cited environmental issues of importance in the 21st century by scientists in 50 countries were water quality and quantity along with climate change. Keeping in mind the continuous increase of the human population and the unprecedented urbanization and
industrialization of the developing world, pollution of freshwater is bound to accelerate.

There is no general “Water Pollutants”. Concerning water pollution pressures, distinctions need to be made between different kinds of pollutants.

- Persistent substances which are always dangerous and must be avoided or at least reduced to the minimum possible. Substances ban or restrictions on their trade and use including substitution policies, and technology-derived emission standards are particularly effective instruments as they stimulate technological change.

- Natural organic matter demanding oxygen, which can be degraded biochemically in the natural environment provided the pollution levels are not too high and other risks are well controlled. Integrated water protection planning is suitable if it includes all relevant points and diffuses sources and considers seasonal and other variations in water flow.

- Nutrients which feed excessive growth in water bodies leading to eutrophication and can make water unfit for human consumption and other uses.

Water pollution is partly driven by inadequate economic development, especially industrial development and uncontrolled urbanization. More recently, pollution from agriculture and aquaculture has gained prominence.

However, it is quite difficult to estimate the extent of water pollution as pollution sources and pollutant categories are often patchy and disperse. General trends are nevertheless obvious. Pollution pressure on water resources decreased in some industrialized area especially pollution from the root source. But problems persist in transitional economics; pressure has also declined, largely as a result of industrial decline. In developing countries, pressures increase, in some cases considerably because of a gap between industrial expansion and environmental policies. Pollution from domestic sewage connected to rapid urbanization and the lack of accompanying waste
water works also remains a major environmental challenge. Worldwide population increase, trade liberalization and globalization potentially contribute to the unsustainable use of water resources and water quality degradation when combined with inadequate planning and inadequate financial resources for the development of strategies that protect the poor.

The impact of water pollution depends on the different levels of pollution, the mix of pollutants, the ecosystem or population affected and the economic activity impaired. Social and economic securities, which are interconnected with environmental security, are significantly impaired by increasing levels of water pollution. To give an example of the external costs of water pollution, the drinking water supply and consequently public health are already impaired or at the risk in developing and increasingly in industrialized regions. The effect of the exposure of aquatic life to freshwater pollution is made obvious by the decline in coastal waters, which directly affects self-sufficient fishing communities and riparian settlements. In short, all expressions of human economic (agriculture, industry, tourism, traditional crafts and so on) and social activities are affected by the rising water pollution leading to real and potential loss of development opportunity with the poor being affected to the greatest extent.

Policy responses always involve the setting of norms for the protection of a “common property” belonging to the (often open) community of water users, and their imposition on that community or the larger society, although the details of approaches vary considerably and depend on the roles of different levels of state. In all cases, policy responses to water pollution make use of at least three types of approaches and instruments, which complement and reinforce one another:

- Planning: Means a formalized process of identifying sources of pollution, pollutants and trends, actual and possible impacts and measures for mitigating pollution. Planning can take the form of administrative coordination or it can be a societal dialogue between agencies of the state
and (representative) members of the public or it can occur within more or less formal water users’ associations as a consensus building process.

- Police Powers: Means monitoring (of water quality), inspection (of installations, products or production practices) and law enforcement (again polluters) by environmental authorities, fiscal authorities, police and prosecutors, depending on the circumstance. The trend is towards requiring a permit for emissions to water bodies, and making that permit conditional on a number of factors, such as minimum requirements for pollution control.

- Economic instruments such as contributions (e.g. to water user associations), charges, tax prices and tariffs for water services, liability and tradable pollution permits. These instruments usually fulfill a financial function (Such as financing specific water management activities or facilities such as sewerage or sewage treatment plants), and always have an incentive effect which can purposefully be used to influence polluters’ behavior. In many cases, economic instruments also have a fiscal function in that the revenue goes in part and rarely as a whole towards general public budgets. All economic instruments have information functions and effects and raise awareness and influence behavior quite effectively as a result.

In water policy including water pollution control, institutions such as social norms, cultural values and even taboos play an important, although often unconscious role.

To summary, clean water is a public or common (or “club”) good and the effectiveness of water pollution control depends in large part on the suitability, stability and adaptability of governance structures and institutions. In practice, water pollution control measures and policies are administered in conjunction with other water resource protection and management functions. Instruments may be specific to addressing water pollution but the organizations involved usually and not because of the public good character or water resources, the transparency of decision making, the access to information and justice (for
conflict resolution) and the involvement of water users is paramount in order to provide democratic legitimacy (“Give the victims a voice”). This applies especially to those water users directly or indirectly affected by water pollution, (elected) representatives of the affected population and to civil society organizations acting for public interest goals (in essence non-profit advocacy NGOs.). As in all cases where a public interest has to be protected against individual action motivated by private gain, there is a risk that corruption leads to ineffective implementation of water (protection) policies and inefficient results. The democratic and judicial accountability of decision-makers, therefore, must also be guaranteed. Additionally, adequate and properly managed financing of pollution prevention is of almost importance for the success of political, co-operative and legislative approaches to resolve the problem of water quality degradation.

**Current situation**

Although only 10% of the renewable water resources are currently withdrawn and only 50% consumed, there are still significant problems concerning human water use. Human activities are degrading the quality of much more water than that are withdrawn and consumed. Developing area which combines high water stress with low per capita income is especially vulnerable to water pollution. Most of such cases are found in arid and semi-arid regions of the Valsad & Navsari where they use most of their available water supplies for irrigation and suffer from lack of pollution controls.

**5.2 Water pollutants**

The main chemical, physical and microbial factors negatively affecting water quality include:

- Organic Pollutants. They easily decompose in water and consume dissolved oxygen leading ultimately to eutrophication. They mainly originate from industrial waste water and domestic sewage, as from seepage of old and new landfillis.
• Nutrients. These include mainly phosphates and nitrates and their increased concentration can lead to eutrophication. They originate from human and animal waste, detergents and runoff agricultural fertilizers.
• Heavy Metals. Such pollution tends to be localized around industrial centers.
• Microbial Contamination from bacteria such as E. coli, protists and amoebae that come from untreated sewage as well as animal husbandry.
• Toxic Organic Compounds. These comprise industrial chemicals, plastics, dioxins, agricultural pesticides, oil and petroleum (group of hydrocarbons) and polycyclic hydrocarbons generated from burning of fuel. The group of Persistent Organic Pollutants (POPs), such as endocrine disrupting chemicals, cyanotoxins, and organizing compounds contained in antifouling paints, continue to be used in large quantities. Many POPs are difficult and costly to analyze and monitor, therefore their potential effect on humans are difficult to establish.
• Traces of Chemicals and Pharmaceutical Drugs from medical waste are hazardous substances that are not necessarily removed by conventional drinking water treatment processes. They are now recognized as carcinogens and endocrine disrupters and pose a great threat to water quality.
• Suspended Particles. These can be either inorganic or organic matter and originate mainly from agricultural practices and land use change such as deforestation, and conversion to pasture at steep slopes leading to erosion.

The following processes, which are intensified by sustainable human activities, also contribute to significant levels of water pollution:
• Salinization, mainly occurring in arid and semiarid regions. Although it can also occur naturally, unsustainable irrigation and inadequate drainage promotes secondary salinization. It can also be the result of irrigation with saltwater, after fresh groundwater has been replaced by the mechanism of sea water intrusion in coastal aquifers due to over-abstraction.
• Acidification, which is connected to the lowering of the pH of the water due to deposition of sulphuric and produced by industrial activity and also through urban emissions.

Obviously, there is a diverse range of water pollutants, each of which is hazardous in different concentrations and originates from diverse activities. Nevertheless, water bodies, have their own self-purification capacity, which depends on a variety of factors such as water volume, flow and chemistry. Aquatic ecosystem and communities interact in a harmonized way to keep the physicochemical status of water body in balance. Thus, water pollution actually refers to the contamination of the water bodies and their substrates when pollution exceeds self-purification capacity or their sink capacity for pollutants. Considering this, the aquatic ecosystems revival can be achieved not only through pollution control measures but also through the ecological restoration of habitats and floodplains, which can significantly contribute to boosting self-purification and improving water quality.

5.2.1 MAIN POLLUTERS

The industrial sector is responsible for the release of a wide array of pollutants and hazardous substances through wastewater, emissions and leaching of industrial leftover. Decommissioned industrial sites and land contaminated by past industrial activities are a significant source of water pollution.

Although some industrial pollutants have been reduced through strict legislation and technology investments in industrialized area during the last 20 years, problems are now increasingly arising from new chemicals and new sectors of industrial activity (Plate 5.2). An issue of increasing concern is also the dumping of waste chemicals in developing area, where legislation is not as strict yet.
In the study area human settlements particularly in cities, namely Umbergaon, Sanjan, Vapi, Atul, Valsad, Navsari, Chikhli, Gandevi are characterized by high population density and uncontrolled growth are ‘hot-spots’ for concentration of pollution (Plate 5.3 & 5.4). Unplanned urbanization and uncontrolled urban agglomerations in the developing area combined with deceased natural sinks, such as drained wetlands around urban centers, harms extensively the local water resources. New and old landfills serving human settlements also consist sources of pollutants through leaching. The industrial estates in Valsad & Navsari district, today are properly connected to waste-treatment plants but in many other rapidly developing areas the sewer network and treatment facilities are not growing as fast as the population.

Finally, in the study area extensive, centrally planned and rapidly modernized practices in agriculture is a major polluter of water as a result of unsustainable land management and cultivation systems the major water pollution issue is that of non-point sources. Often pollution from agriculture, inadequate urban wastewater treatment and management of urban run-off are considered as larger problems than industrial pollution, in terms of absolute quantity of pollution loads, the geographical extent of the pollution problem and the relative difficulty of controlling these sources of pollution. 91
Recently in the coastal parts of the study area aquaculture has also gained prominence as a source of freshwater pollution.

Plate 5.3 (A) View of Polluted Surface Water Body in Valsad Town.

Plate 5.4 View of Dumped Urban Waste in Auranga River by Valsad Nagar Palika.
5.3 Water quality scenario in the study area

In order to have an overall assessment of water quality both civil supply and groundwater; the candidate has collected secondary data from the district Water Supply and Water Resources Departments, viz. GWSSB and Municipal Councils. The data are compiled on an annual basis considering impotent physical and chemical parameters. District wise inference on annual water quality chemistry is given as under:

5.3.1 Civil water supply

The information on drinking water quality data on taluka basis for the years 2007, 2008, 2009, 2010, and 2011 is given as Table 5.1 to 5.3.

A. Valsad District has five taluka, namely Valsad, Dharampur, Pardi, Umbergaon and Kaparada. By and large the drinking water quality as supplied by the local public bodies meets the drinking water standards (Table 5.1).

B. Navsari District is divided into five taluka, namely Navsari, Gandevi, Chikhli, Vansda and Jalalpur. In these administrative units, the drinking water as civil supply to the inhabitants meets the quality norms, prescribed under the drinking water standards (Table 5.2).

C. Dang District - a predominantly hilly and tribal district has its district as well as taluka head quarter’s at Ahwa. The civil water supply at Ahwa to meets the standard civil supply norms (Table 5.3).
### Table 5.1 Water Quality Indices of Drinking Water

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Note: The ionic concentration is in mg/l.
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Note: Ionic Concentration is in mg/l.
Table- 5.3 Water Quality Indices of Drinking Water

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Note: Ionic Concentration is in mg/l.
5.3.2 Groundwater quality

Groundwater quality monitoring is done on regular basis by the government authorities through its own established network of observation wells. Also, the wells utilized for civil supply are monitored for its seasonal changes in groundwater chemical content. Like civil water supply groundwater quality data monitored at the district’s various taluka have been collected by the candidate for its assessment. Looking to the Drinking Water Quality Norms as prescribed by the various International such as WHO and National Agencies like IS & ICMR (Table 3.6); the observed chemical contents in the groundwater samples (Tables 5.4, 5.5 & 5.6) for the years 2007-2011 is within the permissible limits and belongs to potable class.

However, on a broad comparison the groundwater quality for the Dang district is much better than Valsad and Navsari districts. This is attributed to difference in geological environment. Dang being hilly region the continuous and rapid movement of groundwater leads to flushing of vaults, thereby, an overall chemical content in groundwater in Dang is lower as that of other districts.
### Table 5.4  Groundwater Quality Indices of Valsad District.

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<td>36</td>
<td>75</td>
<td>55</td>
<td>9.7</td>
<td>18</td>
<td>122</td>
<td>10</td>
<td>66</td>
<td>0.22</td>
<td>1.28</td>
<td>NIL</td>
<td>154.3</td>
<td>0.85</td>
</tr>
<tr>
<td>2011</td>
<td>Vansda</td>
<td>Navsari</td>
<td>7.4</td>
<td>344</td>
<td>38</td>
<td>47</td>
<td>84</td>
<td>6.4</td>
<td>24</td>
<td>154</td>
<td>NIL</td>
<td>79</td>
<td>0.61</td>
<td>1.54</td>
<td>NIL</td>
<td>142.4</td>
<td>0.69</td>
</tr>
<tr>
<td>2007</td>
<td>Jalalpur</td>
<td>Navsari</td>
<td>8.2</td>
<td>685</td>
<td>86</td>
<td>52</td>
<td>49</td>
<td>2.4</td>
<td>12</td>
<td>145</td>
<td>NIL</td>
<td>60</td>
<td>0.22</td>
<td>1.65</td>
<td>NIL</td>
<td>185.3</td>
<td>0.64</td>
</tr>
<tr>
<td>2008</td>
<td>Jalalpur</td>
<td>Navsari</td>
<td>8</td>
<td>725</td>
<td>64</td>
<td>78</td>
<td>64</td>
<td>3.6</td>
<td>12</td>
<td>120</td>
<td>Nil</td>
<td>91</td>
<td>0.54</td>
<td>1.83</td>
<td>NIL</td>
<td>155.4</td>
<td>0.36</td>
</tr>
<tr>
<td>2009</td>
<td>Jalalpur</td>
<td>Navsari</td>
<td>7.8</td>
<td>886</td>
<td>78</td>
<td>50</td>
<td>80</td>
<td>1.8</td>
<td>12</td>
<td>149</td>
<td>Nil</td>
<td>109</td>
<td>0.82</td>
<td>1.22</td>
<td>NIL</td>
<td>221.2</td>
<td>0.92</td>
</tr>
<tr>
<td>2010</td>
<td>Jalalpur</td>
<td>Navsari</td>
<td>8.3</td>
<td>429</td>
<td>62</td>
<td>53</td>
<td>75</td>
<td>3.4</td>
<td>18</td>
<td>132</td>
<td>NIL</td>
<td>76</td>
<td>0.36</td>
<td>1.46</td>
<td>NIL</td>
<td>162.5</td>
<td>0.76</td>
</tr>
<tr>
<td>2011</td>
<td>Jalalpur</td>
<td>Navsari</td>
<td>8.1</td>
<td>290</td>
<td>89</td>
<td>71</td>
<td>72</td>
<td>2.6</td>
<td>12</td>
<td>155</td>
<td>NIL</td>
<td>82</td>
<td>0.25</td>
<td>1.5</td>
<td>NIL</td>
<td>152.5</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Note: The ionic concentration is in mg/l.
Table. 5.6 Groundwater Quality Indicies of Dangs District.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>TALUKA</th>
<th>DISTRICT</th>
<th>pH</th>
<th>TDS</th>
<th>Ca</th>
<th>Mg</th>
<th>Na</th>
<th>K</th>
<th>CO₃</th>
<th>HCO₃</th>
<th>SO₄</th>
<th>Cl</th>
<th>F</th>
<th>NO₃-N</th>
<th>Bacterial Hardness</th>
<th>Total</th>
<th>NaCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>Ahwa</td>
<td>Dang</td>
<td>7.4</td>
<td>344</td>
<td>38</td>
<td>47</td>
<td>84</td>
<td>6.4</td>
<td>24</td>
<td>159</td>
<td>Nil</td>
<td>76</td>
<td>0.45</td>
<td>3.54</td>
<td>NIL</td>
<td>174.2</td>
<td>0.54</td>
</tr>
<tr>
<td>2008</td>
<td>Ahwa</td>
<td>Dang</td>
<td>7.6</td>
<td>844</td>
<td>49</td>
<td>30</td>
<td>45</td>
<td>1.5</td>
<td>24</td>
<td>145</td>
<td>Nil</td>
<td>93</td>
<td>0.22</td>
<td>0.95</td>
<td>NIL</td>
<td>136.9</td>
<td>0.52</td>
</tr>
<tr>
<td>2009</td>
<td>Ahwa</td>
<td>Dang</td>
<td>8.2</td>
<td>256</td>
<td>62</td>
<td>45</td>
<td>68</td>
<td>4.8</td>
<td>12</td>
<td>123</td>
<td>Nil</td>
<td>79</td>
<td>0.51</td>
<td>1.54</td>
<td>NIL</td>
<td>142.4</td>
<td>0.69</td>
</tr>
<tr>
<td>2010</td>
<td>Ahwa</td>
<td>Dang</td>
<td>7.4</td>
<td>344</td>
<td>38</td>
<td>47</td>
<td>29</td>
<td>6.9</td>
<td>12</td>
<td>140</td>
<td>Nil</td>
<td>76</td>
<td>0.45</td>
<td>3.54</td>
<td>NIL</td>
<td>174.2</td>
<td>0.54</td>
</tr>
<tr>
<td>2011</td>
<td>Ahwa</td>
<td>Dang</td>
<td>8.2</td>
<td>256</td>
<td>62</td>
<td>45</td>
<td>68</td>
<td>6.9</td>
<td>12</td>
<td>140</td>
<td>Nil</td>
<td>122</td>
<td>0.33</td>
<td>1.25</td>
<td>NIL</td>
<td>188.3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Note: The ionic concentration is in mg/l.
5.4 Secular changes in groundwater levels & quality

It’s an established fact that the precipitation constitutes major input parameter in water balance equation and normally considered to be the main component of recharge to the groundwater system. Therefore, aquifer which has been a repository of groundwater always responds to rainfall input. If rainfall is more there is pronounced rise in water table or contrariwise.

The groundwater level is also responding to its rate of abstraction. In a situation where in rate of recharge and abstraction equals, groundwater system is considered to be in harmony. However, in case the abstraction exceeds the recharge the water level fall, irrespective of rainfall and its impact is seen as an overall water quality deterioration. Total Dissolved Solids (TDS) has been considered as on indicator parameter for assessing groundwater quality deterioration ascribed to an exceeded pace of exploitation for a long term period.

The candidate’s endeavour to look this aspect through already available information on long term ground water levels and quality monitoring been carried out by GWRDC (Gujarat Water Resources Development Corporation). The GWRDC is state funded organization involved in development and management of states’ water resources. It has a state wide network of observation wells which are seasonally monitored for groundwater levels and quality changes.

5.5. Long term change in groundwater storage

Groundwater storage is subjected to annual change in response to monsoon recharge and annual abstraction for domestic, agriculture and industrial uses. Changes in groundwater storage one side show strong influence of rainfall input, if it fails the manifestation is reflected in depletion of storage. However, it recovers during successive phase of good monsoon.
Other side, the developmental and demographic growths lead to increase in groundwater storage. It further worsens during the failure of monsoon and increased dependency on groundwater storage.

Aquifers response to recharge and groundwater demand (abstraction) can be monitored for their seasonal changes on water table fluctuations and quality changes. Realizing this very fact, the candidate has made an attempt to study spatial and temporal behavior of aquifers in his study area using secondary data gathered from GWRDC.

Groundwater table behavior for the duration of 10 years (May 2000 to 2009) (Table 5.7) has been studied through categorization of water table depths and 10 years changes in groundwater storage in terms of overall fall/decline and rise.

A. Valsad District

Decadal monitoring of water levels through 92 numbers of observation wells suggests that 53 wells show an overall rise in water table ranging between 0.05-7.20 m (Table 5.8). Almost 25% show there has been a perceptible rise in water table up to 2.0 m rise. This rise in groundwater table/storage is by and large is seen in the areas having canal irrigation, which invariably lead to rise in water levels due to retuned irrigation seepage and non-utilization of groundwater resources.

Contrary to this, 38 observation wells show an overall decline in groundwater storage. The maximum decline is in the depth range of up to 2 m has been observed in 34 (64%) observation wells (Table 5.8). Further 5 wells show decline between 2-4 m. This decline in groundwater storage is along the coastal tract of the district thriving on heavy industrial growth and urban setup, thereby, excessive with drawl due to increased demand.

B. Navsari District

This district also shows more or less similar trend in groundwater storage change. Out of 57 observation wells, 36 wells display rise in
groundwater storage where in up to 2m rise is observed in 14 (39%) observation wells (Table 5.8). Almost 21 observation wells shows overall decline in groundwater storage. The maximum decline up to 2 m is observed in 17 (47%) wells. The causative factors for this displayed rise and fall in groundwater storage remained same as that of Valsad district.

C. Dang District

It’s being rocky – hilly forested and tribal region shows different set up. The order of seasonal water table fluctuation is invariably high. Out of 30 numbers of observation wells, well hydrographs of 12 wells show rise in groundwater storage. Whereas, out of 8 wells almost 50% of wells show decline in groundwater storage ranging between 2-4 m (Table 5.8).
## Table 5.7
Status of Water Levels & Their Annual and Decadal Changes (Unconfined Aquifer) in the Study Area

<table>
<thead>
<tr>
<th>District</th>
<th>No. of Wells analysed</th>
<th>Depth of water level(m)</th>
<th>No. of wells &amp; Percentage in different Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td><strong>MAY 2000</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valsad</td>
<td>53</td>
<td>1.28</td>
<td>38.86</td>
</tr>
<tr>
<td>Navsari</td>
<td>36</td>
<td>1.1</td>
<td>14.72</td>
</tr>
<tr>
<td>Dangs</td>
<td>12</td>
<td>1.6</td>
<td>16.36</td>
</tr>
<tr>
<td><strong>MAY 2009</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valsad</td>
<td>82</td>
<td>2.2</td>
<td>39.8</td>
</tr>
<tr>
<td>Navsari</td>
<td>58</td>
<td>1.8</td>
<td>17.57</td>
</tr>
<tr>
<td>Dangs</td>
<td>20</td>
<td>2.8</td>
<td>15.7</td>
</tr>
<tr>
<td><strong>OCTOBER 2009</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valsad</td>
<td>82</td>
<td>0.4</td>
<td>34.56</td>
</tr>
<tr>
<td>Navsari</td>
<td>58</td>
<td>0.95</td>
<td>8.6</td>
</tr>
<tr>
<td>Dangs</td>
<td>20</td>
<td>0.33</td>
<td>8.95</td>
</tr>
</tbody>
</table>

Source: GWRDC-2009
### Table 5.8 Status of Water Levels and Their Annual & Decadal Changes (Unconfined Aquifer) in the Study Area

<table>
<thead>
<tr>
<th>District</th>
<th>No. of Wells Analysed</th>
<th>NO. of Wells</th>
<th>Range of Fluctuation (m)</th>
<th>No. of wells &amp; percentage in different Ranges</th>
<th>NO. of Wells</th>
<th>Range of Fluctuation (m)</th>
<th>No. of wells &amp; percentage in different Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Average</td>
<td>0 to 2 (m)</td>
<td>2 to 4(m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
<td>7.2</td>
</tr>
<tr>
<td>Valsad</td>
<td>53</td>
<td>14(26.42%)</td>
<td>0.05</td>
<td>7.2</td>
<td>1.18</td>
<td>13(24.53%)</td>
<td>0(0.00%)</td>
</tr>
<tr>
<td>Navsari</td>
<td>36</td>
<td>15(41.67%)</td>
<td>0.1</td>
<td>2.42</td>
<td>0.93</td>
<td>14(38.89%)</td>
<td>1(2.78%)</td>
</tr>
<tr>
<td>Dangs</td>
<td>12</td>
<td>4(33.33%)</td>
<td>0.01</td>
<td>11.06</td>
<td>3.28</td>
<td>5(25.00%)</td>
<td>0(0.00%)</td>
</tr>
</tbody>
</table>

**MAY 2000 TO MAY 2009**

|          |                       |              |             |             |              | 0.05       | 4.05       | 0.38   | 64(78.05%) | 1(1.22%)   | 1(1.22%)     |             |             |             |             |             |
|----------|-----------------------|--------------|-------------------------|-----------------------------------------------|--------------|-------------------------|-----------------------------------------------|
| Valsad   | 82                    | 16(19.51%)   | 0.05       | 0.45       | 0.14          | 16(19.51%) | 0(0.00%) | 0(0.00%) | 66(80.49%) | 0.02       | 4.05         | 0.38       | 64(78.05%) | 1(1.22%) | 1(1.22%) |
| Navsari  | 58                    | 7(12.07%)    | 0.05       | 0.2        | 0.1           | 7(12.07%)  | 0(0.00%) | 0(0.00%) | 51(87.93%) | 0.05       | 0.75         | 0.28       | 51(87.93%) | 0(0.00%) | 0(0.00%) |
| Dangs    | 20                    | 4(20.00%)    | 0.05       | 0.1        | 0.07          | 4(20.00%)  | 0(0.00%) | 0(0.00%) | 16(80.00%) | 0.05       | 1            | 0.33       | 16(80.00%) | 0(0.00%) | 0(0.00%) |

Source: GWRDC-2009
5.5.1 Long term changes in groundwater quality

Drastic reduction in groundwater storage leads to an overall water quality deterioration, attributed to abundance of dissolved constituents at the base of aquifer or through seawater intrusion in the coastal aquifers. Further, groundwater quality tends to change seasonally. In post-monsoon quality normally improves due to an overall dilution through the one of the important quality indices giving insight on changes in water quality on seasonally, annually and/or long term basis.

The candidate through available secondary data from GWRDC has attempted to look into groundwater quality changes, specifically for drinking purpose (TDS = 1500mg/l Maximum Permissible).

District wise data on TDS, its concentration ranges (Table 5.9 & 5.10) does not show any significant change in groundwater quality during the assessment period May, 2000–May, 2009, except in case of Navsari District. There has been almost 100% increase in percentage of wells showing TDS range between 2500-5000 mg/l during the last 10 years. This may be attributed to water logging problem in canal irrigation area or seawater intrusion in the coastal aquifer.

Otherwise, overall behavior of groundwater system at quality seems to be satisfactory.
<table>
<thead>
<tr>
<th>District</th>
<th>Total No. of Wells Monitored</th>
<th>TDS in mg/l</th>
<th>TDS No. of wells &amp; percentage in different Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min Max</td>
<td>0 to 500(mg/l) 500 to 1000(mg/l) 1000 to 2000(mg/l) 2000 to 2500(mg/l) 2500 to 5000(mg/l) &gt; 5000 (mg/l)</td>
</tr>
<tr>
<td>Valsad</td>
<td>53</td>
<td>230 2060</td>
<td>24(45.28%) 23(43.40%) 5(9.43%) 1(1.89%) 0(0.00%) 0(0.00%)</td>
</tr>
<tr>
<td>Navsari</td>
<td>36</td>
<td>230 2800</td>
<td>11(30.56%) 13(36.11%) 9(25.00%) 2(5.56%) 1(2.78%) 0(0.00%)</td>
</tr>
<tr>
<td>Dangs</td>
<td>12</td>
<td>270 570</td>
<td>11(91.67%) 1(8.33%) 0(0.00%) 0(0.00%) 0(0.00%) 0(0.00%)</td>
</tr>
<tr>
<td>Valsad</td>
<td>82</td>
<td>190 2150</td>
<td>40(48.78%) 35(42.68%) 6(7.32%) 1(1.22%) 0(0.00%) 0(0.00%)</td>
</tr>
<tr>
<td>Navsari</td>
<td>58</td>
<td>250 4380</td>
<td>20(34.48%) 18(31.03%) 15(25.86%) 2(3.45%) 3(5.17%) 0(0.00%)</td>
</tr>
<tr>
<td>Dangs</td>
<td>20</td>
<td>120 540</td>
<td>19(95.00%) 1(5.00%) 0(0.00%) 0(0.00%) 0(0.00%) 0(0.00%)</td>
</tr>
<tr>
<td>Valsad</td>
<td>82</td>
<td>120 1530</td>
<td>54(65.85%) 25(30.49%) 3(3.66%) 0(0.00%) 0(0.00%) 0(0.00%)</td>
</tr>
<tr>
<td>Navsari</td>
<td>58</td>
<td>120 2970</td>
<td>24(41.38%) 20(34.48%) 11(18.97%) 1(1.72%) 2(3.45%) 0(0.00%)</td>
</tr>
<tr>
<td>Dangs</td>
<td>20</td>
<td>100 440</td>
<td>20(100 %) 0(0.00%) 0(0.00%) 0(0.00%) 0(0.00%) 0(0.00%)</td>
</tr>
</tbody>
</table>

Source: GWRDC-2009
### Table 5.10 Status of Water Quality (TDS) and Their Annual & Decadal Changes (Unconfined Aquifer) in the Study Area (MAY 2000 TO MAY 2009)

<table>
<thead>
<tr>
<th>District</th>
<th>No. of Wells Analysed</th>
<th>NO. of Wells Fluctuation (m)</th>
<th>Range of Fluctuation</th>
<th>No. of wells &amp; percentage in different Ranges</th>
<th>TDS Range of Fluctuation</th>
<th>TDS No. of wells &amp; percentage in different Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>0 to 500 (mg/l)</td>
<td>500 to 1000 (mg/l)</td>
<td>&gt; 1000 (mg/l)</td>
</tr>
<tr>
<td>Valsad</td>
<td>53</td>
<td>10</td>
<td>710</td>
<td>20 (37.74%)</td>
<td>1 (1.89%)</td>
<td>0 (0.00%)</td>
</tr>
<tr>
<td>Navsari</td>
<td>36</td>
<td>10</td>
<td>910</td>
<td>11 (30.56%)</td>
<td>1 (2.78%)</td>
<td>0 (0.00%)</td>
</tr>
<tr>
<td>Dangs</td>
<td>12</td>
<td>20</td>
<td>290</td>
<td>3 (75.00%)</td>
<td>0 (0.00%)</td>
<td>0 (0.00%)</td>
</tr>
</tbody>
</table>

**Source:** GWRDC-2009