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Research Article

# Comparative Study over the years of Ground Water Quality in Bhubaneswar City

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***Abstract***

*Most of the water requirement for Bhubaneswar city is met from ground water supplies. So it is essential to know the quality of ground water for suitability in drinking purposes. In view of that a study was therefore undertaken to see the quality of ground water. For that nine sampling points were taken for water sampling in three different seasons ( winter, summer, rainy) for two consecutive years of 2009 and 2010. The results obtained has been compared with the standards. The yearly average of all the parameters were calculated and compared graphically. From the results correlation co-efficient among different parameters has been calculated. Most of the parameters are found below permissible limit in most of the locations, except high quality of iron was found in most of the samples. All the samples found to have highly turbid. The ground water of the study area was with respect to TC,FC are below the WHO limit. From correlation coefficient it was found that EC, TH, $Cl^-$, TDS have strong correlation with each other. Iron was found to be negatively correlated with $F^-$.*

***Keywords:*** *Ground water quality, Pollution, Correlation coefficient*

## Introduction

Pollution of ground water has been reported for a number of cities throughout the world. Dependence on ground water resources is growing due to paucity and pollution of surface water bodies. Bhubaneswar the present state capital of Odisha have a huge population use ground water for drinking and other purposes. A number of dug and tube wells have been constructed to meet the short supply of water. Some of these wells are located vicinity of the open sewerage drain which carries a very high potency of inorganic and microbial contaminants. Unfortunately the age old sewerage canal is not cleaned or maintained properly and there is every possibility of contamination of the ground water by the leakage of sewerage through the badly damaged wall and bottom. MSW (Municipality Solis Waste ) has also its share towards ground water contamination. MSW is heterogeneous in nature and contains paper, plastic, rag, metal, glass pieces, ash, composite matter, dead animals, discarded chemicals, paints, hazardous hospital waste and agricultural residues. Presently most of the MSW in Bhubaneswar city is being disposed unscientifically. During land filling of solid waste, continuous pressure results in the quizzing of a contaminated liquid as leachate which contains dissolved, suspended and microbial contaminants from solid waste. The leachate has high organic contents, soluble salts and other constituents capable of polluting ground water. This polluted ground water is unfit for drinking and causes jaundice, nausea, asthma, and infertility.

The quality of ground water of this area still remains largely uncharted and a possibility of severe contamination looms large. Keeping this in view a systematic study on the groundwater quality was carried out over a period of two years from January 2009 to December 2010, which include various Physico-C

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## Description of study area

Bhubaneswar is located between $20^o12'$N to $20^o25'$N latitude and $85^o44'$E to $85^o55'$E longitude on the western fringe of coastal plain across the main axis of Eastern Ghats in Khurda district of Odisha. The city lies on the western side of the Mahanadi delta on the bank of river Kuakhai ( a distributory of Mahanadi ). Bhubaneswar is situated on the western fringe of the mid-coastal plain of Odisha with an average elevation of 45m above the main sea level. It lies on the low lateritic plateau and the erosion has made its topography a valley and ridge one. Geologically the Bhubaneswar region belongs to the Gondwana landmass, one of the oldest and most stable landmasses in the world. So the rocks range from the

Archaean to the recent period. But the major part of the area is covered with the quaternary alluvium and lateritic soil. Upper Gondwana rocks are grouped as the semi consolidated formations, the older and the younger alluviums which occur to the east of the city are the unconsolidated formations. The depth of the water table ranges from 5-12 m in the lateritic and the weathered sandstones to 40-150 m in the fractured and friable sandstones forming the deeper aquifers that are under semi- confined to confined conditions. The rock types in and around the western parts of the city store water recharged by rainfall. The depth is maximum up to 6m bgl in December that falls to 8m bgl in May.

## Material and methods

To have a through idea regarding ground water quality of Bhubaneswar, nine different locations were chosen. The locations were chosen keeping in mind that all the areas of Bhubaneswar can be covered properly. The detailed locations of sampling points are described in table-01. From each location a particular tube well was chosen and grab sampling was done quarterly from that particular tube well.The samples were collected in plastic and glass bottles as per requirement. Using these samples different physical, chemical and microbiological parameters such as **pH, turbidity, conductivity, total hardness, chloride, total dissolved solids, iron, fluoride, TC, FC** were studied. All chemicals/reagents used were of analytical reagent grade. After sample collection and under preservation, the samples are analyzed in laboratory following water and waste water analysis by **APHA 2000(19$^{th}$ Edition)**

**Table-01** Locations of ground water sampling stations of Bhubaneswar

| Stations | Locations | Code No |
|---|---|---|
| 1 | Khandagiri area | L-01 |
| 2 | Unit-1X area | L-02 |
| 3 | Capital Hospital area | L-03 |
| 4 | Chandrasekharpur area | L-04 |
| 5 | Unit-1 area | L-05 |
| 6 | Samantarapur area | L-06 |
| 7 | Rasulgarh area | L-07 |
| 8 | Laxmisagar area | L-08 |
| 9 | Unit-111 area | L-09 |

## Results and discussion

**pH:** pH of ground water of Bhubaneswar varies between 5.5 to 7.9.Except location -02, none of the samples exceeds WHO limit for drinking water. A little variation in pH was noticed during different seasons . At location-02 the water was found more acidic compared to other locations, it may be due to sampling sources close to sewage channel having higher pH. It is also noticed that in summer the acidic character slightly increases compare to rainy and winter seasons. It may be due to decrease of water level.

**Turbidity:**The turbidity of ground water of Bhubaneswar was found between 1.5 to 66 NTU. No such seasonal variation was observed in the samples except at few stations. All the samples found to have high turbid. Turbidity in ground water should be less than 5NTU. Contaminated ground water systems however can have considerably high turbidity (Well and others,1989,Gschwend and others,1990,Puls andPowell,1992, Backhus and others,1993). High turbidity of ground water of Bhubaneswar may be due to impact of underground soil and rocks.

**Conductivity:**The conductivity of ground water of Bhubaneswar ranged from 100 to 1390 micromho/cm. But a marked spatial variation was observed in the samples. L-06 recorded relatively higher conductance which might be attributed from the sewage contamination. Conductivity of water is dependent upon the ions concentration and ionic mobility of the mineral contents in water. In a simpler way, it is an index of the degree to which water is mineralized.

**Total Hardness:**Total hardness represented by $CaCO_3$ in water samples ranged from 20 mg/l to 146 mg/l during the study period. High values were observed in the samples of L-06. Calcium and Magnesium ions as their bicarbonates, sulphate, and chlorides render the water hard, both temporarily and permanently. High values of hardness observed in the sewage water of study area seemed to have been influenced by their proximity to the sewage drains as higher hardness was observed in samples which are located close to it.

**Chloride:** The chloride content of water samples varies from 15 to 326 mg/l during study period. Higher values were noticed in L-06, rest of the samples were found below permissible limit(250 mg/l) set by WHO. Source of $Cl^-$ in ground water is domestic sewage (Trivedy and Goel, 1984, Karanth,1987 and Narayana 109 and Suresh,1989). Abnormal concentration of chloride may be due to contamination from waste water.

**Total Dissolved Solids:**Total Dissolved Solid (TDS) values indicate the total number of ions present in different forms. The TDS of samples varied from 58 to 981 mg/l within the study period. Samples drawn from L-06 recorded high values of TDS .Higher values of TDS associated with higher residues are normally less potable and may induce an unfavourable physiological reaction in the transit consumer. Those samples which are found to have more TDS may be influenced by some pollution source. A well marked temporal variation was observed in the samples. The samples of summer season exhibit high concentration of TDS compared to other seasons. Drying up of the clay material above the water table during summer period might have led to oxidation which increase the stability of minerals by the infiltrating water during the recharge period.

**Iron:**The analysis of ground water in the study area showed Iron concentration ranging from 0.22 to 7.8 mg/l during the study period. Except L-01, all the stations of

Bhubaneswar recorded much higher values than the prescribed limit by WHO i.e 0.3 mg/L. The iron occurs naturally in the aquifers but levels in ground water can be increased by dissolution of ferrous borehole and hand pumps components. Iron dissolved in ground water is in the reduced iron(ii) form. This form is soluble and normally does not cause any problem by itself. Iron(ii) is oxidized to iron(iii) on contact with oxygen in the air or by the action of iron related bacteria. Iron(iii) forms insoluble hydroxides in water. Iron is generally present in organic waste and as plant debris in soil. Activities in the biosphere may have strong influence on the occurrence of the element in ground water. Higher iron concentration in the ground water could result from interaction between oxidized iron minerals and organic matter or dissolution of $FeCO_3$. This type of water is clear when drawn but soon becomes turbidy and then brown by precipitation of $Fe(OH)_3$ (Hem,1991) which is a common problem in some parts of the study area. The other reasons of higher concentration of the element may be removal of dissolved oxygen by organic matter within the sediments leading to reduced conditions. Under this condition the solubility of iron bearing minerals (Siderite /marcacite) increases leading to enrichment of the dissolved iron in the ground water (White,et.al,1991, Applin and Zhao,1989).

**Flouride:**The fluoride concentration of samples varied from 0.01 to 0.466 mg/l during study period. A little variation was observed among the samples. All the samples are found below permissible limit set by WHO and other regulating organizations. A little increase in the concentration was observed at few locations in all seasons which may be attributed to the geological deposition and geochemistry of the location (Lakshamana et al,1986). As the sewage water contain negligible amount of Flouride, there was no chance of contamination of the ion with the nearest ground water source.

**TC and FC :** The ground water of the study area was safe as none of the locations are above WHO limit for TC and FC .

**Correlation Coefficient:** Statistical techniques are designed to explain complex relations among the variables. Due to the change of physico-chemical characteristics of groundwater of the study area, the compositional behaviour of various ions show wide variation. In the present study, in order to establish the natural process and the sources of pollution , a 8×8 correlation matrix from normalized variables and 6 observations for each point have been computed. It was found that EC, TH, $Cl^-$, TDS have strong co-relation with each other. Iron was found to be negatively co-related with $F^-$.

**Table-02** Co-relation between different parameters for 2009

| | pH | Tubd | Cond | TH | $CL^-$ | TDS | Fe | $F^-$ |
|---|---|---|---|---|---|---|---|---|
| Ph | 1 | | | | | | | |
| Tubd | -.416* | 1 | | | | | | |
| Cond | .165 | -.083 | 1 | | | | | |
| TH | .372 | .004 | .924** | 1 | | | | |
| $CL^-$ | .076 | -.109 | .988 ** | .859* * | 1 | | | |
| TDS | .148 | -.068 | .991** | .914** | .977** | 1 | | |
| Fe | .294 | -.165 | -.161 | -.031 | -.211 | -.164 | 1 | |
| $F^-$ | -.249 | .260 | .073 | -.044 | .095 | .084 | -.666 ** | 1 |

**Table-03** Co-relation between different parameters for 2010

| | pH | Tubd | Cond | TH | $CL^-$ | TDS | Fe | $F^-$ |
|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | |
| Tubd | -.054 | 1 | | | | | | |
| Cond | .082 | .047 | 1 | | | | | |
| TH | .232 | .258 | .912** | 1 | | | | |
| $CL^-$ | .014 | -.037 | .988 ** | .842 ** | 1 | | | |
| TDS | .057 | .083 | .994 ** | .920 ** | .978 ** | 1 | | |
| Fe | .218 | .256 | -.159 | .022 | -.202 | -.193 | 1 | |
| F- | -.251 | -.240 | .139 | .000 | .154 | .161 | -.629 ** | 1 |

## Conclusion and suggestions

From the results obtained and subsequent discussion it was found that the most potential source of ground water contamination from Physico-Chemical as well as microbial point of view is the open top main domestic sewerage running through the drains of the city. Almost all ground water sources located near to the drains are polluted. Hence these tube wells should be abandoned or should not be used for drinking purposes by the residents of that locality. The Physico-Chemical and microbial parameters show that ground water is safe for consumption being with safe limits prescribed by WHO. But the tube wells located adjacent to the unprotected septic tanks are highly contaminated. Awareness should be created among the people to construct protected concrete septic tanks at a safe distance from the tube wells. The high amounts of iron contents found in water samples may be due to the soil which is lateritic in nature or may be due to the age old hand pump contain iron pipe which require immediate replacement with PVC pipes.

The high population density of Bhubaneswar city demanding high volume of water for drinking and bathing. The river water is not attaining the quality of drinking. So ultimately ground water is the main source of water for drinking. As a result there is depletion of groundwater table and also the groundwater is getting contaminated due to unplanned way of discharge of solid waste and domestic waste. we should make a rule in each household and all institutions and offices to make water harvesting in their own building in order to increase the ground water table. Also the Government should take cess for using groundwater and permission should be taken before digging the tube wells. By this way the extravagant use of ground water can be restricted.

**Table-04** Yearly average of physico-chemical and microbial parameters of the year 2009

| S.NO | pH | Turbidity | Conductivity | TH | Cl- | TDS | Iron | F- | TC | FC |
|---|---|---|---|---|---|---|---|---|---|---|
| L-01 | 6.3 | 3.3 | 104 | 22 | 17.7 | 69 | 0.25 | 0.16 | <2 | <2 |
| L-02 | 5.7 | 5.0 | 160 | 23 | 26.7 | 107 | 0.99 | 0.41 | <2 | <2 |
| L-03 | 6.7 | 4.0 | 464 | 91 | 69.3 | 292 | 3.71 | 0.1 | <2 | <2 |
| L-04 | 6.6 | 33.7 | 151 | 39 | 15.7 | 93 | 6.13 | 0.07 | <2 | <2 |
| L-05 | 7.9 | 29.0 | 265 | 67 | 21.3 | 161 | 5.07 | 0.20 | <2 | <2 |
| L-06 | 6.7 | 27.7 | 1316 | 135 | 298 | 829 | 2.27 | 0.20 | <2 | <2 |
| L-07 | 6.3 | 35.3 | 145 | 31 | 21.7 | 91 | 4.87 | 0.11 | <2 | <2 |
| L-08 | 6.3 | 59.3 | 461 | 76 | 79.3 | 298 | 6.13 | 0.10 | <2 | <2 |
| L-09 | 6.5 | 19.0 | 189 | 26 | 33.8 | 115 | 7.4 | 0.06 | <2 | <2 |

**Table-05** Yearly average of physico-chemical and microbial parameters of the year 2010

| S.NO | pH | Turbidity | Conductivity | TH | $Cl^-$ | TDS | Iron | $F^-$ | TC | FC |
|---|---|---|---|---|---|---|---|---|---|---|
| L-01 | 6.3 | 2.0 | 114 | 25 | 18.7 | 75 | 0.36 | 0.17 | <2 | <2 |
| L-02 | 5.7 | 3.1 | 173 | 26 | 26 | 110 | 1.23 | 0.43 | <2 | <2 |
| L-03 | 6.5 | 3.7 | 476 | 95 | 71.3 | 306 | 4.07 | 0.1 | <2 | <2 |
| L-04 | 6.3 | 34.0 | 163 | 45 | 16.7 | 97 | 6.43 | 0.08 | <2 | <2 |
| L-05 | 7.2 | 27.7 | 276 | 71 | 24.7 | 162 | 5.27 | 0.25 | <2 | <2 |
| L-06 | 6.4 | 25.7 | 1321 | 139 | 308.7 | 807 | 2.43 | 0.25 | <2 | <2 |
| L-07 | 6.0 | 33.0 | 154 | 34 | 24 | 92 | 5.1 | 0.15 | <2 | <2 |
| L-08 | 6.2 | 49.0 | 467 | 86 | 80 | 294 | 6.57 | 0.08 | <2 | <2 |
| L-09 | 6.5 | 18.0 | 188 | 29 | 36 | 64 | 7.4 | 0.06 | <2 | <2 |

**Seasonal variation of physico-chemical and microbial parameters of Bhubaneswar for the year 2009 and 2010.**

**Table-06 pH**

| Locations | Winter-09 | Summer-09 | Rainy-09 | Winter-10 | Summer-10 | Rainy-10 |
|---|---|---|---|---|---|---|
| L-01 | 6.3 | 6.2 | 6.6 | 6.4 | 6.1 | 6.5 |
| L-02 | 5.8 | 5.6 | 5.8 | 5.9 | 5.5 | 5.8 |
| L-03 | 6.7 | 6.5 | 6.8 | 6.6 | 6.3 | 6.6 |
| L-04 | 6.6 | 6.4 | 6.8 | 6.4 | 6 | 6.5 |
| L-05 | 7.9 | 7.9 | 7.8 | 7.5 | 6.9 | 7.3 |
| L-06 | 6.7 | 6.7 | 6.8 | 6.5 | 6.1 | 6.6 |
| L-07 | 6.2 | 6.2 | 6.4 | 6 | 5.8 | 6.4 |
| L-08 | 6.3 | 6.3 | 6.4 | 6.4 | 6 | 6.2 |
| L-09 | 6.5 | 6.5 | 6.6 | 6.6 | 6.2 | 6.6 |

**Table-07 Turbidity (NTU)**

| Locations | Winter-09 | Summer-09 | Rainy-09 | Winter-10 | Summer-10 | Rainy-10 |
|---|---|---|---|---|---|---|
| L-01 | 3 | 3 | 4 | 2 | 1.5 | 2.5 |
| L-02 | 4 | 5 | 6 | 3 | 2.2 | 4 |
| L-03 | 4 | 4 | 4 | 4 | 3.4 | 3.8 |
| L-04 | 33 | 32 | 36 | 34 | 30 | 38 |
| L-05 | 29 | 28 | 30 | 30 | 25 | 28 |
| L-06 | 27 | 27 | 29 | 28 | 21 | 28 |
| L-07 | 35 | 33 | 38 | 34 | 30 | 35 |
| L-08 | 58 | 54 | 66 | 50 | 45 | 52 |
| L-09 | 19 | 18 | 20 | 20 | 16 | 18 |

**Table-08 Conductivity (micromho/l)**

| Locations | Winter-09 | Summer-09 | Rainy-09 | Winter-10 | Summer-10 | Rainy-10 |
|---|---|---|---|---|---|---|
| L-01 | 104 | 108 | 100 | 106 | 126 | 110 |
| L-02 | 160 | 168.7 | 152.4 | 166 | 184 | 170 |
| L-03 | 458 | 490 | 444 | 469 | 522 | 436 |
| L-04 | 150 | 158 | 146.4 | 158 | 172 | 160 |
| L-05 | 265 | 272 | 258 | 265 | 290 | 272 |
| L-06 | 1300 | 1371 | 1278 | 1282 | 1390 | 1290 |
| L-07 | 145 | 154 | 138 | 150 | 169 | 144 |
| L-08 | 460 | 472 | 452 | 454 | 486 | 460 |
| L-09 | 190 | 192 | 186 | 184 | 199 | 180 |

**Table-09 Total Hardness (mg/l)**

| Locations | Winter-09 | Summer-09 | Rainy-09 | Winter-10 | Summer-10 | Rainy-10 |
|---|---|---|---|---|---|---|
| L-01 | 22 | 24 | 20 | 24 | 28 | 22 |
| L-02 | 23 | 24 | 22 | 25 | 29 | 24 |
| L-03 | 90 | 94 | 88 | 92 | 104 | 90 |
| L-04 | 39 | 40 | 38 | 42 | 52 | 40 |
| L-05 | 67 | 68 | 66.2 | 69 | 74 | 69 |
| L-06 | 135 | 140 | 130.2 | 138 | 146 | 132 |
| L-07 | 31 | 32 | 30.9 | 34 | 38 | 30 |
| L-08 | 75 | 80 | 72 | 76 | 98 | 84 |
| L-09 | 26 | 28 | 25 | 28 | 32 | 28 |

**Table-10 Chloride(mg/l)**

| Locations | Winter-09 | Summer-09 | Rainy-09 | Winter-10 | Summer-10 | Rainy-10 |
|---|---|---|---|---|---|---|
| L-01 | 17 | 18 | 18 | 18 | 22 | 16 |
| L-02 | 24 | 28 | 28 | 22 | 32 | 24 |
| L-03 | 64 | 72 | 72 | 66 | 78 | 70 |
| L-04 | 15 | 16 | 16 | 16 | 18 | 16 |
| L-05 | 20 | 22 | 22 | 20 | 28 | 26 |
| L-06 | 294 | 300 | 300 | 290 | 326 | 310 |
| L-07 | 21 | 22 | 22 | 22 | 26 | 24 |
| L-08 | 78 | 80 | 80 | 78 | 82 | 80 |
| L-09 | 33.5 | 34 | 34 | 34 | 39 | 36 |

**Table-11 TDS(mg/l)**

| Locations | Winter-09 | Summer-09 | Rainy-09 | Winter-10 | Summer-10 | Rainy-10 |
|---|---|---|---|---|---|---|
| L-01 | 69 | 70 | 67 | 74 | 82 | 70 |
| L-02 | 106 | 110 | 104 | 108 | 115 | 108 |
| L-03 | 290 | 318.5 | 267.2 | 306 | 332 | 280 |
| L-04 | 90 | 102.7 | 86.2 | 94 | 110 | 89 |
| L-05 | 158 | 176.8 | 148.6 | 156 | 180 | 152 |
| L-06 | 722 | 981 | 784 | 718 | 899 | 804 |
| L-07 | 90 | 100 | 84 | 92 | 98 | 86 |
| L-08 | 300 | 306 | 289 | 292 | 312 | 280 |
| L-09 | 112 | 124.8 | 108 | 64 | 70 | 58 |

**Table-12 Total Iron(mg/l)**

| Locations | Winter-09 | Summer-09 | Rainy-09 | Winter-10 | Summer-10 | Rainy-10 |
|---|---|---|---|---|---|---|
| L-01 | 0.26 | 0.28 | 0.22 | 0.31 | 0.46 | 0.32 |
| L-02 | 1.0 | 1.01 | 0.98 | 1.1 | 1.6 | 1.0 |
| L-03 | 3.58 | 4.0 | 3.56 | 3.6 | 4.4 | 4.2 |
| L-04 | 6.2 | 6.4 | 5.8 | 6.4 | 7.0 | 5.9 |
| L-05 | 5.1 | 5.1 | 5.0 | 5.3 | 5.6 | 4.9 |
| L-06 | 2.2 | 2.4 | 2.2 | 2.3 | 2.6 | 2.4 |
| L-07 | 4.85 | 4.95 | 4.8 | 4.9 | 5.4 | 5.0 |
| L-08 | 6.1 | 6.3 | 6.0 | 6.2 | 6.9 | 6.6 |
| L-09 | 7.4 | 7.6 | 7.2 | 7.4 | 7.8 | 7.0 |

**Table-13 Flouride (mg/l)**

| Locations | Winter-09 | Summer-09 | Rainy-09 | Winter-10 | Summer-10 | Rainy-10 |
|---|---|---|---|---|---|---|
| L-01 | 0.158 | 0.175 | 0.144 | 0.16 | 0.184 | 0.158 |
| L-02 | 0.406 | 0.455 | 0.355 | 0.412 | 0.466 | 0.404 |
| L-03 | 0.098 | 0.106 | 0.096 | 0.07 | 0.14 | 0.098 |
| L-04 | 0.074 | 0.081 | 0.07 | 0.084 | 0.089 | 0.07 |
| L-05 | 0.202 | 0.223 | 0.188 | 0.24 | 0.32 | 0.2 |
| L-06 | 0.198 | 0.223 | 0.192 | 0.24 | 0.3 | 0.22 |
| L-07 | 0.11 | 0.121 | 0.101 | 0.146 | 0.161 | 0.134 |
| L-08 | 0.104 | 0.112 | 0.098 | 0.108 | 0.116 | 0.01 |
| L-09 | 0.06 | 0.068 | 0.056 | 0.061 | 0.072 | 0.052 |

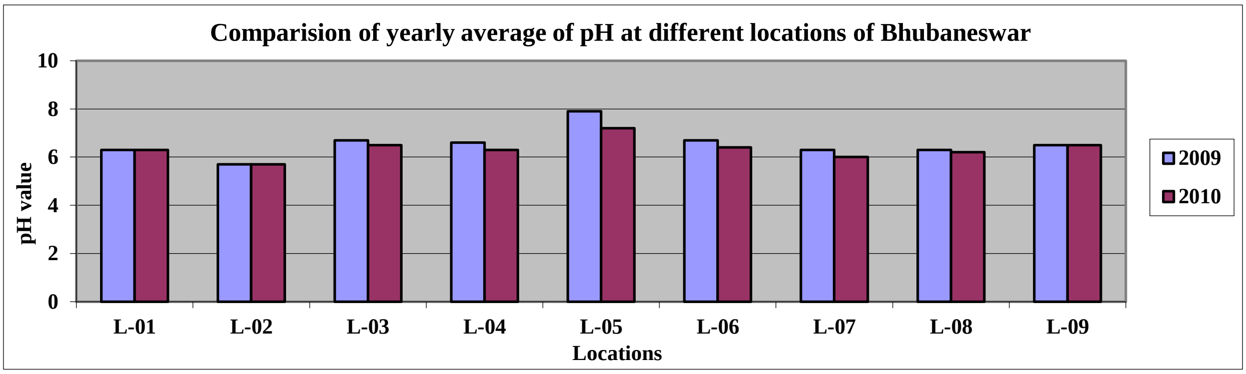



**Fig- 01**

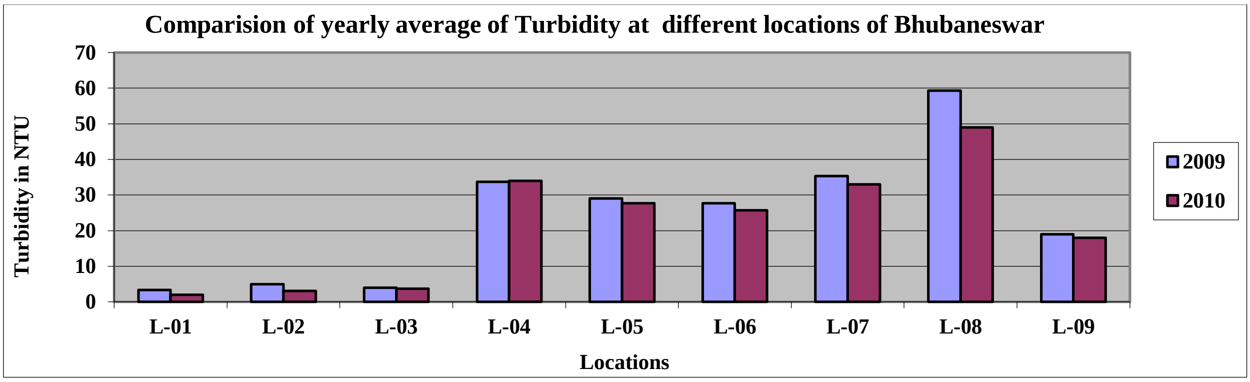



**Fig- 02**

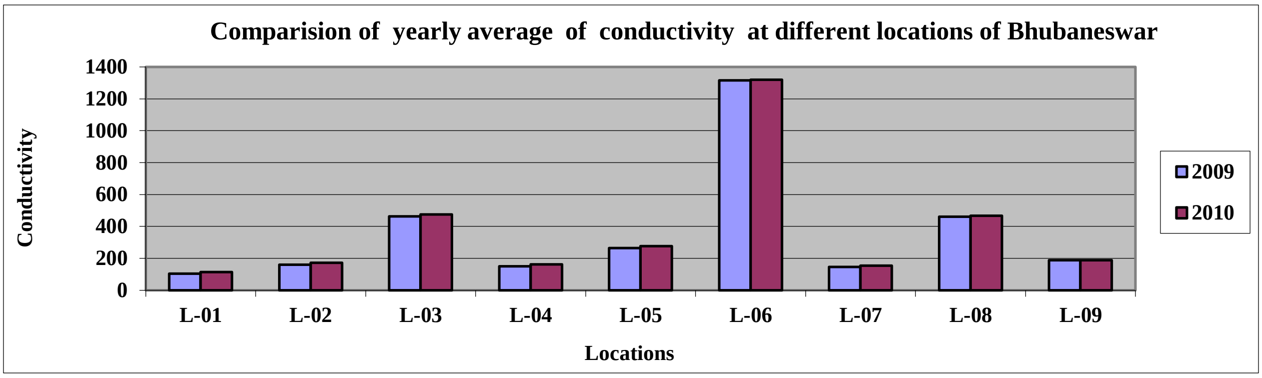



Fig- 03

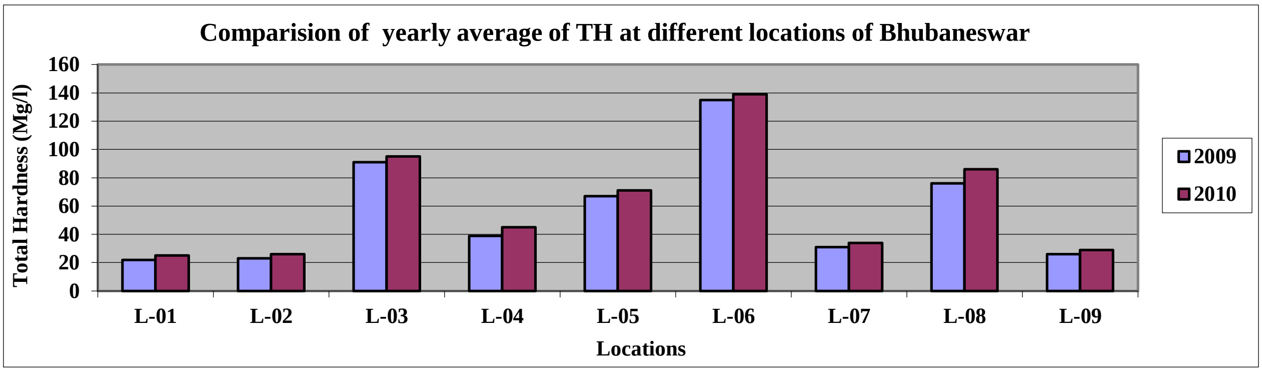



Fig-04

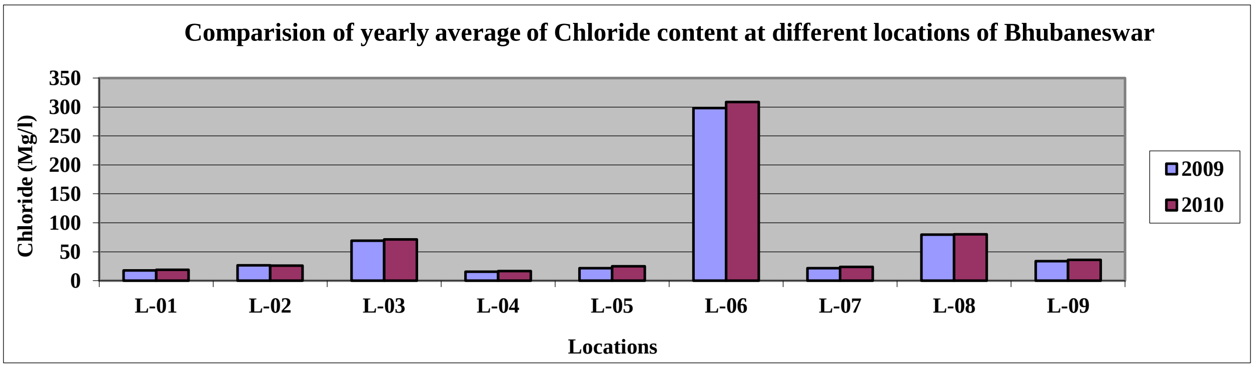



Fig-05

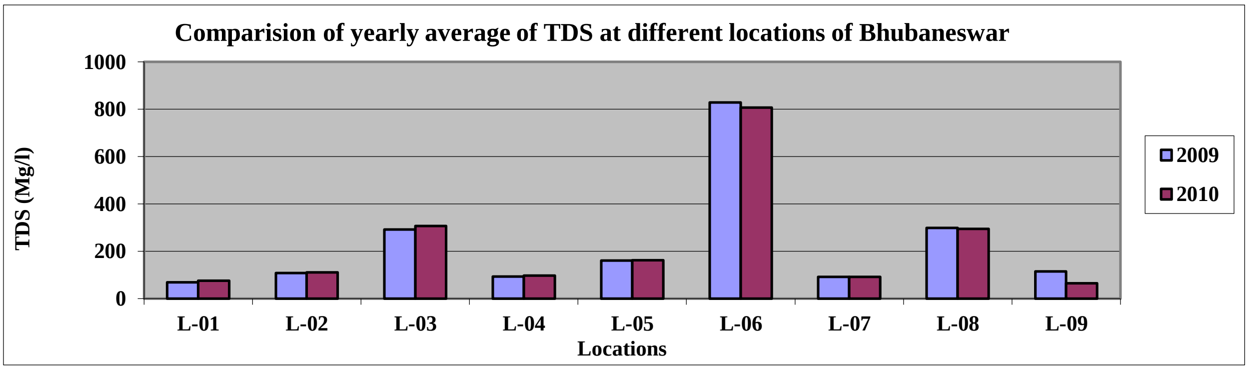
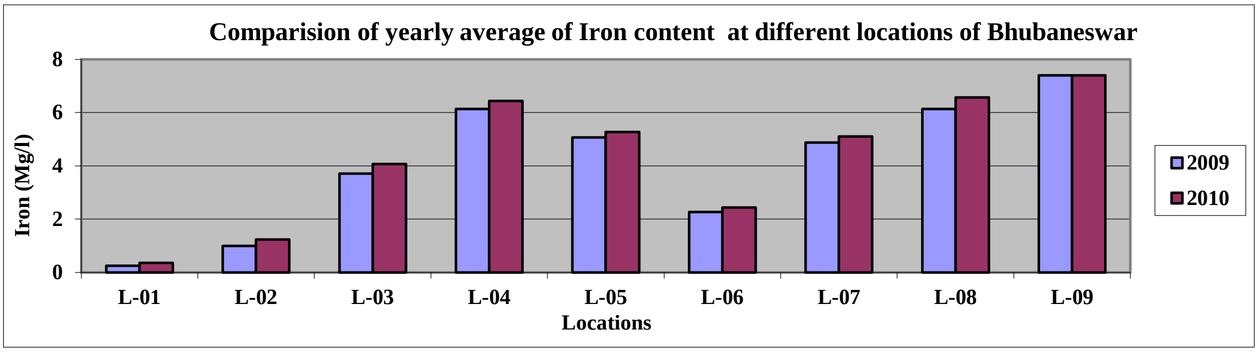



Fig-06

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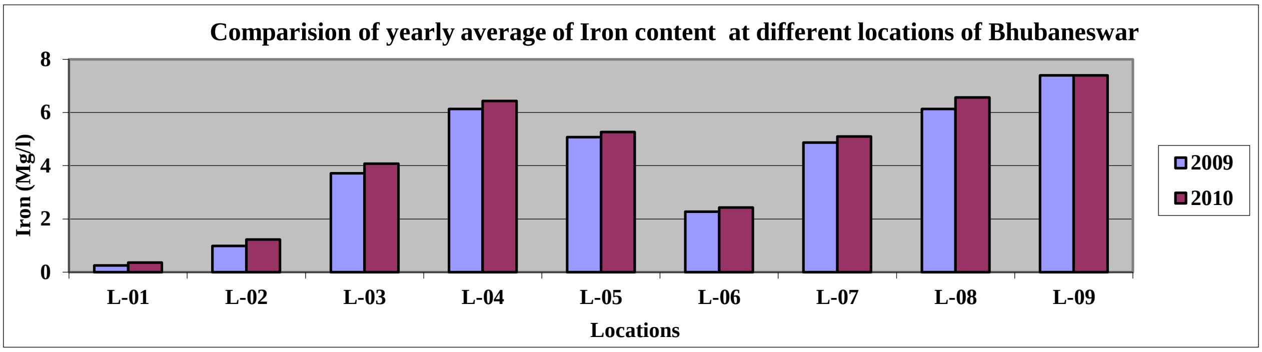


Fig-08

**Seasonal variation of physico-chemical and microbial parameters of the year 2009 and 2010**

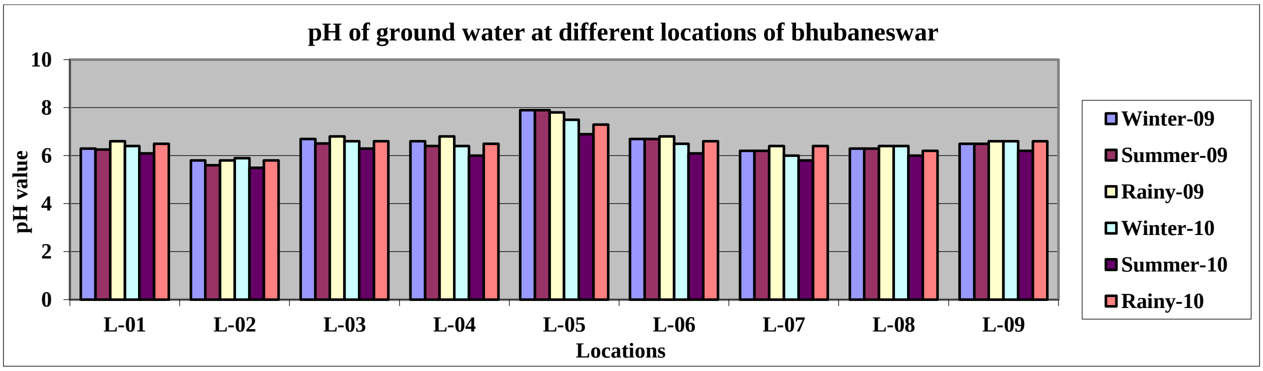


Fig-09

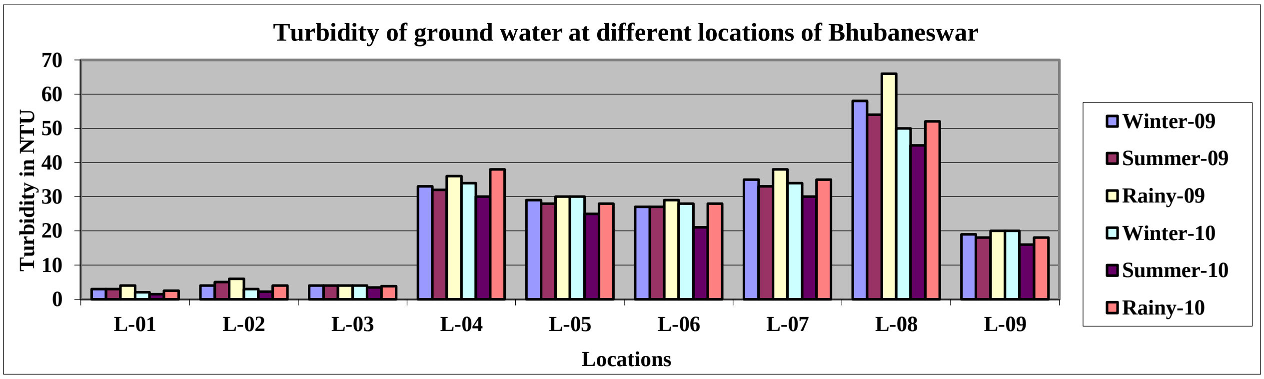


Fig-10

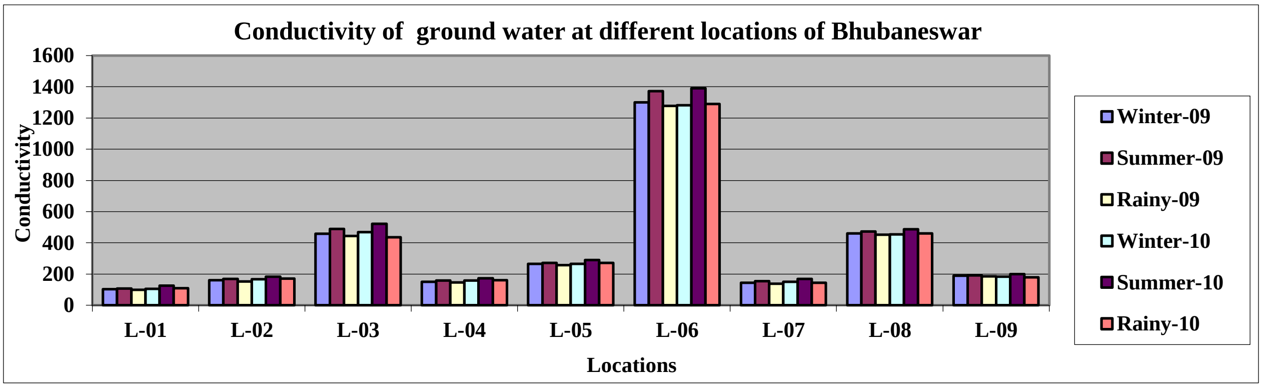


Fig-11

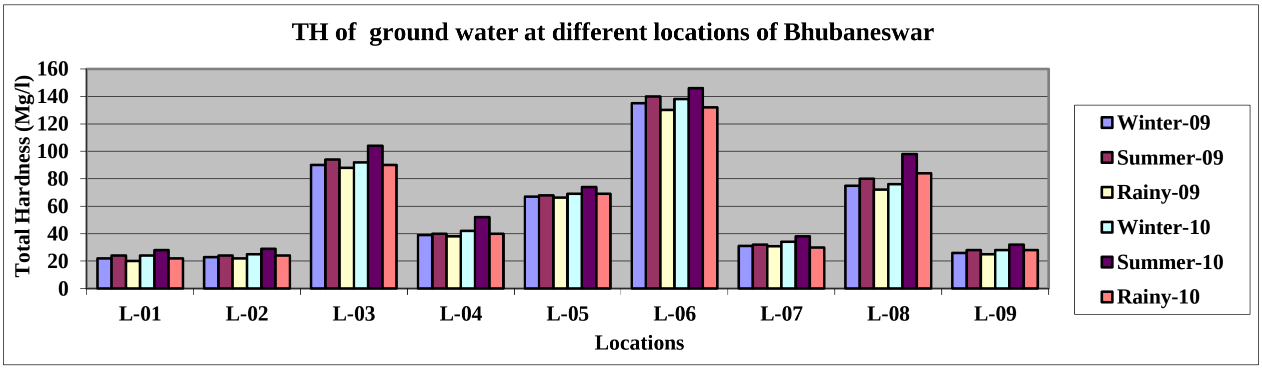


Fig-12

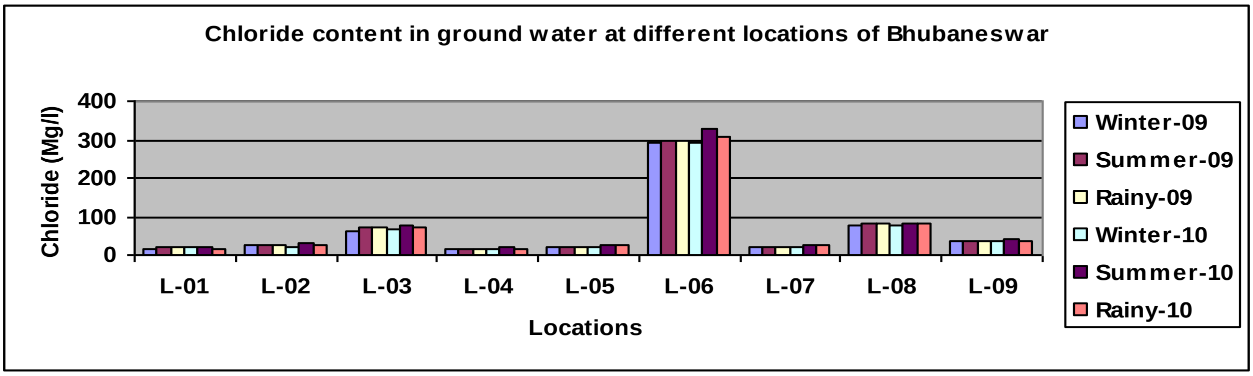


Fig-13

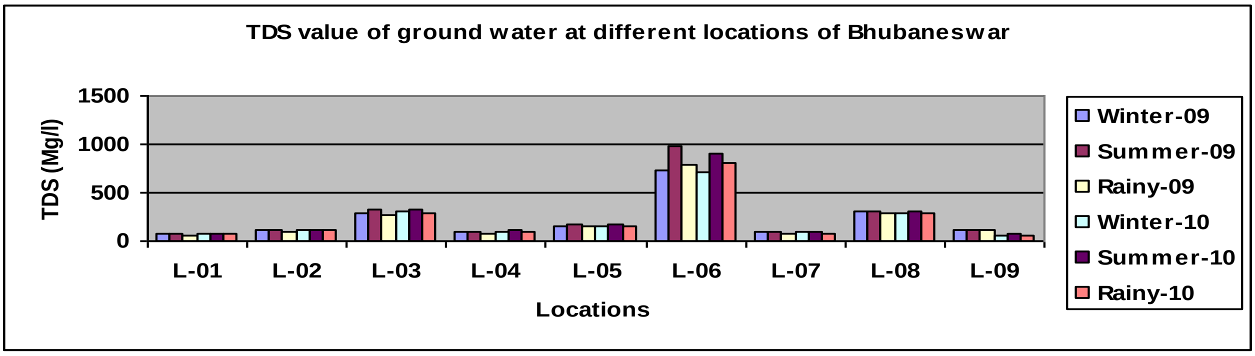


Fig-14

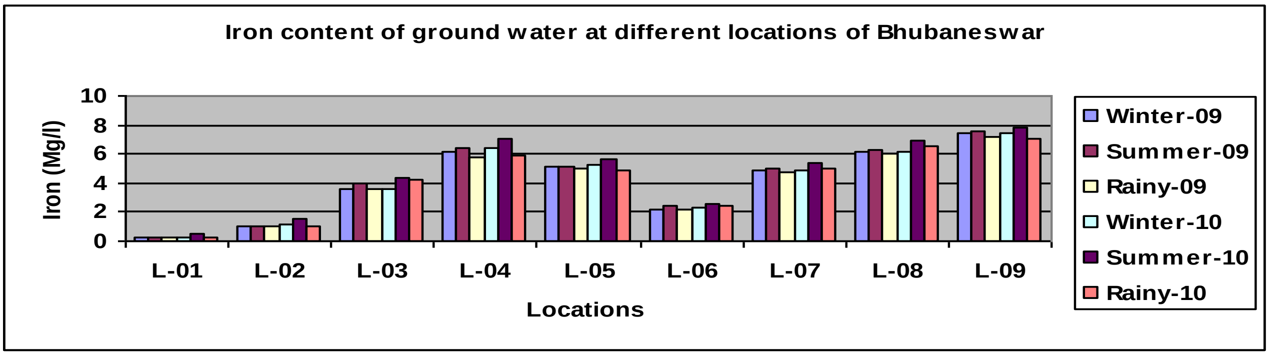


**Fig-15**

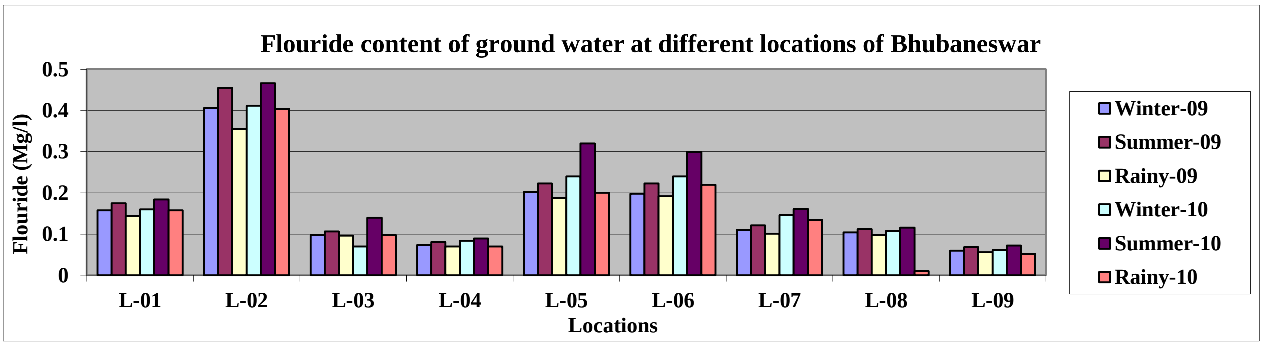


**Fig-16**

## References


APHA 2000.standard methods for estimation of water and waste water ( 20th edn). *American public Health Association, Washington D.C.*

Das jyotirmayar, Sahoo Ram Krishna and B K Sinha.2002. Urban ground water pollution:A case study in Cuttack city .*Indian J.Env.Prot*, 22(3):95-103.

Johnson E E.1996. ground water and wells .Inc.saint Paree. Minnesota.

Mohanty S K.2001. Strategy to control environmental pollution in Koraput area. PhD thesis . *Utkal University, Bhubaneswar.*

Patel Niraj K. and B K Sinha.1998. Study of pollution load in the ponds of Burla area near Hirakud Dam of Orissa. *J.Env. Ppollution*, 5(2):32-40.

WHO. 1971. International standard for drinking water (3rd edn ). *World Health Organisatoin, Geneva*.

Who 1993. Guidelines for drinking water quality. *World Health Organisation, Geneva.*