Drinking water quality management through various physico-chemical parameters and health hazard problems with their remedial measures in Bhubaneswar city of Odisha, India

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ABSTRACT

The physico-chemical and bacteriological study and its adverse effect in Bhubaneswar the capital of Odisha well known as temple city of India are undertaken. Water samples from 39 different locations were collected in postmonsoon period. Standard procedures were adopted to calculate their physical, chemical and biological parameters. Bhubaneswar has a typical interface of sedimentary terrain along with alluvium deposits, has got variability in its physical and chemical constituents. The variations are also remarkable on the basis of their lithological aspects. Different parameters of groundwater samples were examined using WHO and Indian Standards to find their suitability for drinking and domestic purposes. Systematic approach between various parameters is simultaneously carried out. Each element and its impact to health problem are discussed. The results are then interpreted to provide the details of the quality and quantity problem suggesting whether water of different locations are within the permissible limit for drinking and domestic purposes as far as different standards are concerned.

A new approach has been developed that aims at identifying more important scenarios to evaluate the environmental and environment-induced human health effects. Water samples collected from different locations from different sources according to the availability are thoroughly studied and the results with their remedial measures are interpreted with retrospective suggestions.

Keywords: Groundwater, physico-chemical parameters, palatability, pathogenic

1. Introduction

One third of the daily average fluid intake by a human is thought to be derived from food and the remaining water requirement is met from consuming fluids. The total daily intake of both potentially harmful contaminants and beneficial elements directly associated with the total amount and type of water that is being consumed affects health and safety of life. Drinking water, regardless of its source, may be subjected to one or more of a variety of treatment processes aimed at improving its safety and/or aesthetic quality. These processes are selected in each case according to the source water and the constituents and contaminants that require removal. Surface water often undergoes coagulation, sedimentation, rapid sand filtration and disinfection. Ground waters, which are naturally filtered, usually endure less/no treatment that could be limited to disinfection alone. The quality of water depends on the management of anthropogenic discharges as well as the normal physico-chemical characteristics of the catchment areas (Efe.et.al, 2005). Bhubaneswar the capital of Odisha, more commonly
known as the temple city of India was planned originally for 40,000 people with an area of 1684 hectares is now accommodating about 7.50 lakhs population in an area of about 135 sq. km. The city continued to grow and has achieved the highest growth rates experienced by any other capital city in the country. The city continued to grow both due to natural increase as well as migration. About 26 percent of the growth was due to natural increase, while the rest 74 percent was the result of migration during the decade 1981-1991. This created an acute crisis in getting contaminant free water. Sufficient drinking and domestic water is now a days a big problem to meet the demand of the inhabitants. Industries, software hubs and educational institutes are grooming day by day. The surrounded area to the city is a green belt, which too requires ample water for agricultural purpose. On the contrary pollution free water meeting the demands for all purposes is a matter of concern.

Figure 1: Study area representing different locations

To make the people concern of such situation, the entire Bhubaneswar area is investigated and water samples from the available dug wells and bore wells were collected. The physical, chemical and biological parameters of each sample were thoroughly studied and analysed. The deficiency and sufficiency limit for the parameters are investigated. The common diseases created due to such problems are notified and suggestions are given to overcome from such situation.

2. Area under Study
A century of industrialization and technical advancement has brought forth rapid urbanization in Odisha. The urbanization pattern is skewed with the larger cities growing at much faster rate. Orissa State is the 24th most urbanized and 5th least urbanized state in India with about 14.97 percent of urban population. The urban decadal growth during the last decade (1991-2001) has been enormous with a growth rate of about 30.28 percent. Noteworthy that the state’s population during the last decade has grown by about 14 percent while that of the urban population has grown at almost at double this rate (Figure 1). Consequent to the decision to shift the capital from Cuttack to Bhubaneswar, the original plan of the capital city was drawn up in 1948. The modern city of Bhubaneswar was designed by the German Architect Otto H. Koeingsberger. The city was designed for a population of 40,000 based on “neighborhood principles” with administration being designated as the primary function. The population density of the city works out to about 4,800 persons per sq. km inside the municipal area of 135 sq. km as per the 2001 census. The gross density has been increasing from 638 persons per sq. km in 1951 to 4800 persons per sq.km in 2001 as per the respective census figures. Present population of the city within the municipal limits is expected to be about 7.50 lakhs approximately (2005/2006) and accordingly, density works out to 5555 persons per sq. km. This growth has become a matter of concern for the planners to meet with the demand of much safer water for the public.

2.1 Location, Communication and Regional Setting

Bhubaneswar the capital of the state of Odisha and located at a distance of about 64 km from Puri, the abode of Lord Jagannath forming the apex of the “Golden Triangle” with Konark and Puri as the other two points. The city is well connected by road and railway network to the urban centers in the state and neighboring states. The city is also connected by air to all the major metropolitan cities across India and is administered by the BMC and the administrative jurisdiction of BMC extends over an area of 135 sq. km. By virtue of its strategic and central location, salubrious climate and propulsive effects of a growing city, its regional setting can be best illustrated through three characteristics, viz. Odisha state; Capital Sub-Region; and Golden Triangle of Tourism. Bhubaneswar City being the Capital City of the state has been functioning as an administrative city and hub for tertiary economic activities like services, trade and commerce. In addition, recent development indicates that the city is fast emerging as a preferred destination of health and education for the state. In future, the economy is likely to be driven by the core sub-sectors like tourism related activities, knowledge based industries, small-scale and household service industries and services, trade & commerce.

2.2 Topography and Drainage Channels

Bhubaneswar is located in Khurda District of Coastal Orissa, about 40 km west of north Bay of Bengal between Latitude 20° 12’ to 20° 25’ North and Longitude 85° 44’ to 85° 55’ East on the western fringe of the coastal plain across the main axis of the Eastern Ghats. The city lies on the Mahanadi Delta. It lies on the west bank of river Kuakhai, which is a tributary of river Mahanadi, 30 km southeast of Cuttack. The river Daya branches off at Kathjodi and flows along the southeastern part of the city. Bhubaneswar lies on the western fringe of the mid-coastal plain of Odisha with an average elevation of 45 metres above mean sea level (Figure 1). It is located on a low laterite plateau and continuous erosion has shaped the topography into valleys and ridges. The rivers Kuakhai, Bhargavi and Daya flow on the southeastern fringe of the city. Enormous hillock and forests are spread across the northern, western and southern parts. Topographically, the city can be divided into two major parts.
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namely western upland and eastern lowland with the South-Eastern Railway forming the main divide between these two broad units. With the ground sloping from west to east, the city has a natural advantage for drainage. On the whole, ten drainage channels are identified in the development area of the Bhubaneswar city.

2.3 Climate, Geology and Landuse

Bhubaneswar enjoys a healthy and moderately humid tropical climate. Average annual rainfall is about 1498 mm falling from June to September (76 percent) and from October to December (13 percent). Temperature and humidity are high throughout the year. The maximum temperature ranges from 31°C to 43°C and minimum from 12°C to 24°C. The maximum humidity ranges from 71 percent to 83 percent and minimum from 41 percent to 81 percent. The prevailing wind direction is southwest while the monsoon wind blows from south and southwest. The western part is high land with hard soil and permits growth of forests while the eastern part is low with alluvial soil and can be considered suitable for agricultural purposes. The general soil condition is hard. Laterite stones are visible at some places on the surface. According to the available information with the Govt. on current landuse dates to the year 1994 and is presented in the Table 1. Field surveys were undertaken to assess the current landuse in comparison with the landuse pattern proposed in the Comprehensive Development Plan. It has been generally observed that development is duly guided by the proposed Comprehensive Development Plan. In general, mixed landuse are seen in most parts of the city. The functions such as trade commerce, open spaces, recreational areas, and industries excluding household employment centres, community facilities utilities and services have encroached upon the existing areas meant for residential and other such purposes. It is also observed that the wholesale markets are located in close proximity to tourist attraction areas. The older parts of the city are characterized as mixed landuses.

Table 1: Landuse percentage to total area ratio

| Land use Percentage to Total Area |  |
|----------------------------------|--|
| Residential                       | 8.01  |
| Commercial                        | 0.55  |
| Industrial I                     | 1.68  |
| Institutional & Utilities        | 2.23  |
| Administrative                    | 0.87  |
| Open Space                       | 3.02  |
| Transport & Communication         | 4.31  |
| Water Bodies                      | 2.42  |
| Agriculture                       | 28.06 |
| Vacant Land/Forest Area           | 48.85 |
| **Total Area:**                  | **100.00** |

The present city is rectangular in form, and illustrates signs of development of the city on a vast unutilized undulating plateau. The city has extended in seven different directions during the last few decades by engulfing the fringe villages. This extension has varied length and dimensions from the core of the original temple town, which was supposed to lie at the area having Lingaraj Temple. Availability of government land in the north and the west has aided development of the city. The extension towards the south is totally restricted by the presence of unplanned old city and the low-lying flood plain of the river Daya, the tributary of river...
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Kuakhai. The Comprehensive Development Plan also promotes development in the north rather than the south.

2.4 Methods and procedures of investigation

The entire area of Bhubaneswar is thoroughly studied and locations of bore wells and dug wells were earmarked. One litre of airtight polypropylene sampling bottles was taken for water sample collections. The bottles were sterilized before the collection of the samples. The bottles were rinsed with the proposed collected water samples and the water samples were collected from different locations. The temperature of different water samples was determined at the site by sensitive Red Mercury Thermometer, just after collecting the water samples. The temperature of the water samples were also confirmed by using ion analyzer. pH of the water samples were determined by using field pH meter as well as laboratory pH meter. Turbidity of the samples was found through digital turbidity meter and the respective electrical conductivity as well as total dissolved solids was calculated by EC-TDS meter in the lab. Total suspended solid was determined by the simple process of filtration where as all the chemical properties like Br, Cl, Cu, F, S, K, Na and Fe were analyses through digital Ion-Analyzer using their respective electrodes. The results were later on confirmed through field analysis kit which was used at the place of collection of samples. Standard procedures were adopted using desiccators to find the limitation of bacteriological tests (APHA, 1998).

3. Results and Discussion

Availability of dug wells and bore wells are very less in Bhubaneswar city since maximum residents use municipality water for domestic and drinking purposes. It became a very hectic task to collect the samples. Since chance of contaminate of surface and groundwater is more prevalent in postmonsoon period in comparison to premonsoon so post monsoon water samples are collected so that the water samples may have been contaminated to its maximum extent.

Table 2: Physical Parameters of different locations

| Location          | Temp (°C) | pH   | Conductivity (In mmhos) |
|-------------------|-----------|------|-------------------------|
| Bermunda (DW)     | 21.9      | 6.573| 0.25                    |
| Bermunda (BW)     | 22.1      | 5.223| 0.13                    |
| CRP (BW)          | 22.7      | 5.897| 0.04                    |
| CRP (DW)          | 22.5      | 4.999| 0.07                    |
| Rental (BW)       | 22.3      | 6.86 | 0.086                   |
| Ekamra Kanan (DW) | 21        | 7.341| 0.018                   |
| Behera Sahi (BW)  | 21.5      | 6.53 | 0.107                   |
| Beherasahi (DW)   | 21.7      | 6.393| 0.154                   |
| Gopabandhu (BW)   | 24.2      | 5.846| 0.08                    |
| Gopabandhu (DW)   | 24        | 6.244| 0.08                    |
| Unit-6 (BW)       | 24.9      | 5.883| 0.07                    |
| Unit-6 (DW)       | 24.1      | 5.846| 0.06                    |
| Unit-4 (BW)       | 23.2      | 6.641| 0.1                     |
| PMG (BW)          | 24.1      | 5.879| 0.06                    |
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| SL NO. | Location              | Turbidity (In NTU) | TDS (in mg/l) | TSS (in mg/L) |
|--------|-----------------------|--------------------|---------------|---------------|
| 1      | Bermunda (DW)         | 7.1                | 0.008         | 0.02          |
| 2      | Bermunda (BW)         | 12                 | 0.052         | 0.054         |
| 3      | CRP (BW)              | 665                | 0.096         | 0.07          |
| 4      | CRP (DW)              | 9                  | 0.009         | 0.02          |
| 5      | Rental (BW)           | 225                | 0.036         | 0.02          |
| 6      | Ekamra Kanan (DW)     | 82                 | 0.056         | 0.026         |
| 7      | Behera Sahi (BW)      | 375                | 0.076         | 0.064         |
| 8      | Beherasahi (DW)       | 8.5                | 0.048         | 0.004         |
| 9      | Gopabandhu (BW)       | 65.4               | 0.1           | 0.022         |
| 10     | Gopabandhu (DW)       | 12.5               | 0.064         | 0.01          |
| 11     | Unit-6 (BW)           | 326                | 0.108         | 0.02          |
| 12     | Unit-6 (DW)           | 235                | 0.008         | 0.048         |
| 13     | Unit-4 (BW)           | 681                | 0.084         | 0.014         |
| 14     | PMG (BW)              | 342                | 0.0132        | 0.038         |
| 15     | Unit-2 (BW)           | 4.6                | 0.112         | 0.03          |

Table 3: Physical Parameters of different locations
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| Location          | Na (in ppm) | K (in ppm) | F (in ppm) | Fe (in ppm) |
|-------------------|-------------|------------|------------|-------------|
| 1 Bermunda (DW)   | 4.385       | 12.02      | 0.732      | Less than 0.1 |
| 2 Bermunda (BW)   | 13.34       | 46.82      | 1.028      | Less than 0.1 |
| 3 CRP (BW)        | 15.39       | 51.63      | 1.831      | Less than 0.1 |
| 4 CRP (DW)        | 11.88       | 34.47      | 1.331      | Less than 0.1 |
| 5 Rental (BW)     | 12.98       | 21.47      | 0.728      | Less than 0.1 |
| 6 Ekamra Kanan (DW) | 10.1       | 58.06      | 1.156      | Less than 0.1 |
| 7 Behera Sahi (BW) | 11.415      | 45.06      | 1.279      | Less than 0.1 |
| 8 Beherasahi (DW) | 8.768       | 57.78      | 0.855      | Less than 0.1 |
| 9 Gopabandhu (BW) | 11.978      | 29.52      | 4.618      | Less than 0.1 |
| 10 Gopabandhu (DW)| 12.38       | 34.47      | 3.723      | Less than 0.1 |
| 11 Unit-6 (BW)    | 11.88       | 36.68      | 2.916      | Less than 0.1 |
| 12 Unit-6 (DW)    | 8.19        | 35.98      | 1.99       | Less than 0.1 |
| 13 Unit-4 (BW)    | 12.56       | 36.68      | 2.81       | Less than 0.1 |
| 14 PMG (BW)       | 12.56       | 34.8       | 1.43       | Less than 0.1 |
| 15 Unit-2 (BW)    | 10.53       | 30.73      | 2.883      | Less than 0.1 |
| 16 Bapuji Nagar (DW) | 13.1       | 34.14      | 2.151      | Less than 0.1 |
| 17 Bapuji Nagar (BW) | 4.53       | 24.42      | 1.842      | Less than 0.1 |

Table 4: Chemical Parameters of different locations
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| Location           | Cl (in ppm) | Br (in ppm) | SO₃ (in ppm) | Cu (in ppm) |
|--------------------|-------------|-------------|--------------|-------------|
| 1 Bermunda (DW)    | 162.6       | 115.2       | 2.277        | 9.694       |
| 2 Bermunda (BW)    | 65.78       | 120.786     | 0.767        | 13.2        |
| 3 CRP (BW)         | 44.411      | 271.34      | 5.495        | 2.088       |
| 4 CRP (DW)         | 88.188      | 96.61       | 5.586        | 3.007       |
| 5 Rental (BW)      | 33.455      | 135.842     | 4.064        | 10.61       |
| 6 Ekamra Kanan (DW)| 11.166      | 149.213     | 28.1         | 45.96       |
| 7 Behera Sahi (BW) | 99.811      | 128.08      | 28.3         | 12.26       |
| 8 Beherasahi (DW)  | 71.333      | 113.48      | 3.819        | 8.287       |
| 9 Gopabandhu (BW)  | 93.644      | 115.168     | 9.175        | 16.27       |
| 10 Gopabandhu (DW) | 72.666      | 134.269     | 6.609        | 11.41       |
| 11 Unit-6 (BW)     | 83.822      | 117.977     | 5.07         | 34.45       |
| 12 Unit-6 (DW)     | 74.633      | 183.033     | 16.34        | 98.06       |
| 13 Unit-4 (BW)     | 224.7       | 118.539     | 19.78        | 3.569       |
| 14 PMG (BW)        | 103.277     | 136.966     | 66.02        | 15.92       |
| 15 Unit-2 (BW)     | 228         | 139.101     | 4.01         | 14.88       |
| 16 Bapuji Nagar (DW)| 139.666   | 150.441     | 9.97         | 12.12       |
| 17 Bapuji Nagar (BW)| 63.588     | 141.91      | 48.36        | 12.64       |
| 18 Lingaraj (DW)   | 93.644      | 117.977     | 4.868        | 8.963       |
| 19 Tankapani (BW)  | 33.03       | 137.415     | 10.76        | 6.591       |
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Table 6: Biological Parameter of different locations

| Location                  | Permissible/Non Permissible |
|---------------------------|-----------------------------|
| 1  Bermunda (DW)          | Permissible                  |
| 2  Bermunda (BW)          | Permissible                  |
| 3  CRP (BW)               | Permissible                  |
| 4  CRP (DW)               | Permissible                  |
| 5  Rental (BW)            | Permissible                  |
| 6  Ekamra Kanan (DW)      | Permissible                  |
| 7  Behera SAHI (BW)       | Permissible                  |
| 8  Beherasahi (DW)        | Permissible                  |
| 9  Gopabandhu (BW)        | Permissible                  |
| 10 Gopabandhu (DW)        | Permissible                  |
| 11 Unit-6 (BW)            | Permissible                  |
| 12 Unit-6 (DW)            | Permissible                  |
| 13 Unit-4 (BW)            | Permissible                  |
| 14 PMG (BW)               | Permissible                  |
| 15 Unit-2 (BW)            | Permissible                  |
| 16 Bapuji NAGAR (DW)      | Permissible                  |
| 17 Bapuji NAGAR (BW)      | Permissible                  |
| 18 Lingaraj (DW)          | Permissible                  |
| 19 Tankapani (BW)         | Permissible                  |
| 20 Tankapani (DW)         | Permissible                  |
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| 21 | Rabi Takies (DW) | Permissible |
| 22 | Rasulgarh (DW) | Permissible |
| 23 | Chakeisiani (DW) | Permissible |
| 24 | Ideo Colony (DW) | Permissible |
| 25 | Mancheswar (BW) | Permissible |
| 26 | Mancheswar (DW) | Permissible |
| 27 | Vanivihar (BW) | Permissible |
| 28 | Sahid Nagar (BW) | Permissible |
| 29 | Unit-9 (BW) | Permissible |
| 30 | Acharya Vihar (BW) | Permissible |
| 31 | Nalco Nagar (DW) | Permissible |
| 32 | Nalco Nagar (BW) | Permissible |
| 33 | Sailashri Vihar (DW) | Permissible |
| 34 | Sailashri Vihar (BW) | Permissible |
| 35 | Sailashri Vihar (BW) | Permissible |
| 36 | Kanan Vihar (BW) | Permissible |
| 37 | Kanan Vihar (DW) | Permissible |
| 38 | Khandagiri (DW) | Permissible |
| 39 | Sundarpada (DW) | Permissible |

The different physico-chemical parameters including the bacteriological conditions of the collected samples are shown in Table 2 to Table 5. The comparison of the parameters with the WHO standards are shown in Table 6. The different parameters with respect to locations are plotted in Figure 2 to Figure 14. The permissible line for each parameter if any is drawn basing on WHO, IS and ICMR standards to represent the localities exceeding the limit. The temperatures of the samples lie in between $21^0C$ to $24^0C$. This implies that the water available is comparatively cooler. The electrical conductivity ranges from 0.02 to 0.2. The other parameters are shown in the successive tables.

**Table 7: Comparison of water quality of the study area with different standards for drinking purpose**

| Properties                  | Standard Values                                                                 | Observed values          |
|-----------------------------|--------------------------------------------------------------------------------|--------------------------|
|                             | Drinking water (Maximum Permissible limit)                                    |                          |
| pH                          | 7.0 – 8.5                                                                       | 4.978 – 7.341            |
| Turbidity in NTU            | 10.0 – 25.0                                                                     | 1.1 – 681.00             |
| T.D.S. in mg/l              | 500.0                                                                           | 0.002 – 0.116            |
| Na$^+$ in mg/l              | 200.0                                                                           | 4.385 – 73.65            |
| Cl$^-$ in mg/l              | 250.0                                                                           | 10.45 – 228.00           |
| Fe$^{2+}$ in ppm            | 0.3 – 1.0                                                                       | Less than 0.1            |
| Cu$^{2+}$ in ppm            | 0.05 – 1.5                                                                      | 2.088 – 153.30           |
| SO$_3^{2-}$ in ppm          | 150 – 400                                                                        | 0.767 – 19.78            |
| F$^-$ in ppm                | 0.6 – 1.2                                                                        | 0.672 – 4.618            |
| Bacteriological             | I-coli form/100ml                                                               | Within the permissible limit |
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Figure 2: Temperature of the study area

Figure 3: pH of the study area

Figure 4: EC of the study area
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Figure 5: Turbidity of the study area

Figure 6: TDS of the study area

Figure 7: TSS of the study area
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Figure 8: Chloride concentration of the study area

Figure 9: Bromide concentration of the study area

Figure 10: Sulphate concentration of the study area
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Figure 11: Copper concentration of the study area

Figure 12: Sodium concentration of the study area

Figure 13: Potassium concentration of the study area
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Figure 14: Fluoride concentration of the study area

The standards suggested by different organizations for drinking water purpose have been presented through histograms (Figure 2 to Figure 14). Each studied parameter with respect to the standard is compared for the complete analysis. Each parameter versus location is illustrated graphically except iron, since range-calculation of iron was analysed. Each parameter is marked with a dotted permissible line if any.

4. Environmental Impact on Human Health

There exist two types of water pollutants. The first is the point source and nonpoint source. Point sources of pollution occur when harmful substances are emitted directly into a body of water. A second is the nonpoint source delivers pollutants indirectly through environmental changes. Nonpoint sources are much more difficult to control. Pollution is caused when silt and other suspended solids, such as soil, wash off plowed fields, construction and logging sites, urban areas, and eroded river banks when it rains. Under natural conditions, lakes, rivers, and other water bodies undergo Eutrophication, an aging process that slowly fills in the water body with sediment and organic matter as in the case of Bindusagar lake. Microbiological pollutants in such static water bodies have tremendous effect evidenced by their ability to cause sickness. Drinking water, regardless of its source, may be subjected to one or more of a variety of treatment processes aimed at improving its safety and/or aesthetic quality. These processes are selected in each case according to the source water and the constituents and contaminants that require removal. Ground waters, used by many of the occupants in Bhubaneswar are often naturally filtered, usually undergo less treatment that could be limited to disinfection alone. Treating the palatable water, other processes may include pH adjustment, softening, addition of corrosion control chemicals, alkalinity adjustment, carbon filtration/adsorption, membrane filtration, slow sand filtration and supplemental fluoridation which is rarely found as individual uses since people in Bhubaneswar mostly depend on municipal water which is itself treated by using disinfectants like chlorine, chloramines, ozone etc. The salinity problem in the study area is itself negligible due to the distance factor of Bhubaneswar from the coast.
4.1 Diseases caused and their remedial measures

The details of the permissible limit and the range of observed values are shown in the table given below.

4.1.1 Chloride

As water can diffuse freely throughout the body, gains or losses of water alter the amount of water in the body spaces in proportion to the normal volume of these spaces. Excessive ingestion of chloride in form of NaCl tends to increase the asthmatic pressure of extra cellular fluid, this is closely related to the sensation of thirst, thus the regulation of the body fluids & electrolytes is achieved by the kidney, mainly under the influence of two hormones, antidiuretic hormone & aldosterone, so that the amount of water & electrolytes in the body alter the excretion of water and minerals by the kidney. Predominant salt depletion is the result of less of Na\(^+\) & Cl\(^-\) from the extracellular space in excess of water loss. This occurs after excessive, if the fluid drunk contains no salt, it may also develop in patients who lose large amounts of gastric juice, the volume of which is replaced by fluid given intravenously containing little or no NaCl. Normally, daily loss of fluid is the equivalent of about 1.5-2.0 litres of water together with about 4g. of chloride, 90%-95% of chloride loss occurs in the urine, 4%-8% in the feaces and about 2% in sweat. The total obligatory loss of chloride per day amounts to approximately 530 mg (Dietary Standard of Canada, 1975). The details of the chloride shown in the table 4 suggests that neither any of the sample is below nor excess in terms of its concentration.

4.1.2 Bromide

These are among the feeblest of the hypnotics and by themselves, in moderate doses, can be depended upon to produce only sedation. In virtue of their effects on the motor cortex, bromides have been used in the treatment of epilepsy, along with the other epileptic drugs. The body tissues do not distinguish between Br and Cl ion. Bromides freely replace chlorides in the body and the kidney excretes the two salts indifferently. After prolonged administrations 1/5\(^{th}\) of the halogen content of the body may be bromides. it follows that a decreased intake of chlorides lead to retention of bromides, if given instead. This is made use of in treating epileptics. Conversely increased salt intake clears the bromide out of the tissues. Table 4 shows the concentration of Bromide which discards any adverse effect. Bromides have no specific effect in depressing the motor functions and this is not manifest except in doses which also induce general depression, dullness and apathy.

4.1.3 Sulphate

Daily intake of sulphate from drinking water is extremely variable. It is poorly absorbed from the human intestine; it slowly penetrates into the cellular membranes of mammals and is rapidly eliminated through the kidneys. Sulphate doses of 1.00 to 2.00 gms. have a cathartic effect on humans, resulting in the purgation of the alimentary canal. Magnesium sulphate at concentrations above 100 mg/l acts as a purgative in normal humans but concentrations below this are apparently physiologically harmless. The reported minimum lethal dose of magnesium sulphate in mammals is 200 mg/kg. of body weight. No adverse health effect have been noted for concentration of sulphate less than 400 mg/l. Sulphate with sodium interferes with the normal functioning of the intestine (Iqbal et.al., 1995). The range of SO\(_3\) in the study area ranges from 0.767 to 130.00 mg/l which suggest that the water samples are safe from any health hazard problem.
4.1.4 Copper

It seems to be a physiological element as it is essential for chlorophyll of plants. A minute quantity of copper is said to act as catalyst for iron utilization in the human body. Copper is found in food but it absorbed with some difficulty. Among the tissues liver contains largest amount. All other tissues contain minimal amount. Copper sulphate is a local astringent. Sometimes the ceystal is applied to exuberant granulation in chronic ulcers. Copper is occasionally used in phosphorous poisoning as copper phosphate is non-absorbable. Copper sulphate is also an intestinal astringent and mucosal irritant. it is therefore used as an emetic in 1% solution. Toxic action may sometimes be noted if water supply gets contaminated with copper. Gastro-intestinal disturbances and green line on the gums are noticed. In acute poisoning with Cu, egg-white is to be given as a demulcent in addition to a stomach wash. Abnormal accumulation of copper as a genetic effect is associated with the disease Hepatolenticular degeneration. Severe deficiency of copper causes demineralization of bones, demyelination of neural tissue, anemia, fragility of arteries, myocardial fibrosis, graying of hair (Dara, 2009) Permissible limit of Cu in drinking water ranges from 0.05-1.5 mg/l, and the observed value ranges from 2.088-153.30 mg/l which is a matter of concern as far as health problem is concerned.

4.1.5 Sodium

It is the cheap cation in the extra-cellular fluid. About 50% of body sodium is present in the bone, 40% in the extra-cellular fluid and the remaining 10% in the soft tissues. It is equally important in the extra-cellular fluid for specific function such as influencing cardiac muscle activities (Satyanarayan, 2004). The study area has a sodium percentage ranging from 4.385 – 73.65 mg/l which concludes that the palatable water is safe for drinking purpose.

4.1.6 Potassium

Potassium is found mainly in the cells (about 150m-equiv per litre) gross changes in the concentration of ions, like potassium are known to cause death of the cell or organism, & minor alterations in potassium, can cause major disturbances in neuromuscular irritability. High leakage of potassium from the red cells into the plasma of blood is the result to diabetic ketaris.

Sodium and potassium are the most common cations in biological fluids. Interestingly many cells tend to accumulate potassium ions at the expense of sodium ions. Typically in red blood cells the ratio of potassium to sodium is 7:1 in mammals (Satyanarayan, 2004). Potassium in the study area ranges from 10.984-58.06 mg/l which is much within the maximum permissible limit.

4.1.7 Fluoride

These are not ordinarily used in medicines. Fluorine is widely distributed in nature and is a normal constituent of bones. Excess of fluorine ingested leads to a mottling of teeth. This is found endemically in certain areas where the water supply is thus contaminated. The teeth can be protected and tendencies to caries reduced about 40% by topical applications of fluoride solution. When fluorine is absorbed, it unites with calcium and reduces the blood calcium level. In acute poisoning, the symptoms are nausea, vomiting, diarrhea, cramps in the
abdomen and sometimes clonic convulsions. The excretion is in the urine. In chronic poisoning, joint stiffness and exostoses ‘moth eaten’ bones, calcifications of ligaments and changes in the mandible are seen. Small dose of fluoride less than 1mg/l in drinking water reduces the incidence of dental carries when the maximum levels exceeds 1.5mg/l causing serious health problems (Raseed et al., 2005). A daily dose of 0.7-1.0mg/l is useful for dentine care where as 10-100 ppm. cause skeletal fluorosis and still leads to death. The observed value ranges from 0.67 to 4.618 mg/l where as the maximum permissible limit ranges 0.6 to 1.2 mg/l. Some of the samples contain excessive of fluoride which may create adverse effect.

4.1.8 Iron

The dietary overloading of iron has resulted from prolonged consumption of acid foodstuffs cooked in iron kitchenware (Jacobs, 1977). Long term exposure to iron, particularly Fe₂O₃ has also resulted in “siderosis” (mottling of the lungs). It is suspected that Fe₂O₃ dust might serve as a co-carcinogenic substance (Soman et.al. 1990). The iron requirements of a normal adult 5-10mg per day; women up to menopausal age require more, about 15 mg per day rising up to 20mg during pregnancy and lactation. Children require about 0.5 mg per kg body weight. The total quantity of iron available on a mixed diet varies from 5-20 mg. Only a small portion of this is absorbed ordinarily. Serious toxic effects may follow ingestions of large amounts of soluble iron e.g. sugar coated ferrous sulphate. Local irritant effect with intramuscular and acute cytotoxic effects with intravenous iron is possible. Haemosiderosis (Iron accumulation in the internal organs) with or without fibrotic changes are also possible.

Absorbed iron from breakdown of erythocytes is comparatively non-toxic. In acute poisoning the symptoms are due to a local irritation of the gastro-enteric mucous membrane which may even proceed to necrosis and consequent shock. WHO has suggested a maximum permissible limit 1 ppm where as the sample collection sites show the presence of iron as less than 0.1 mg/l which is less comparison to the reverse studied (Paul et.al., 2010). Positive loading of biological parameters indicates that the healthy state of the eco-system maintained by the proper nutrient supply, phytoplankton growth as well as decomposition of organic materials in the ecosystem (Upadhyay et. al., 1988, Panigrahi et. al., 1999)

5. Conclusion

Bhubaneswar is a vital place in Odisha which has been recently converted from municipality to corporation. Improper drainage facilities, illegal constructions, conversion of green land to residential areas, sewerage exposure, choking of natural drainages, illegitimate withdrawal of groundwater, mammoth population rise without proper infrastructure facility are presently the basic problem of groundwater contamination with a prediction of health hazard problems to come. As far as the fluoride concentration is considered three to four areas are above the permissible limit which is a matter of concern. An advice to every citizen residing in Bhubaneswar is the turbidity which is alarming. Drinking water after boiling and proper filtering is advised to every resident. Similarly, other parameters related to pollution are well studied and interpreted to its maximum extent and utmost care. Every occupant must be aware of deficiency/sufficiency of any parameter either may be physical, chemical or biological. Causes and remedial measures as suggested may be taken into consideration. This may create a green and healthier Bhubaneswar in near future.
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