HEALTH HAZARDS RELATING TO DRINKING WATER IN kAS TOWN SOUTHERN SUDAN SUDAN

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Health Hazards Related to Drinking Water in Kas Town, Southern Darfur, Sudan

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Samir M. Ali Alredaisy**

Abstract

This paper is based on both data provided by Hunting Company on chemical analysis of water in Kas town and fieldwork. The paper attempts to investigate health hazards relating to drinking water in order to designate an integrated environmentally based model for development of sustainable water resources in small towns of Sudan. The main findings attributed health hazards in Kas town to failure to meet international standards concerning chemical properties, as well as the per capita consumption of water per day for man and beast. Chemical analysis of water in Kas town revealed less chlorine and calcium than the world recommended levels. Alkalinity and salinity are excessively higher, while ferrous elements almost equal world recommended levels. The fact that water in Kas fails to meet international standards concerning quantity and quality makes people vulnerable to waterborne diseases.

Key Words: aquifers, chemical pollution, waterborne diseases, community education, sustainable development.

Introduction

Much of the diseases in developing countries have to do with the fact that most people do not have access to safe drinking water. In Africa, there were 300 million people not having access to safe drinking water during 1981-1991 (Nyrumby, 1986), and this figure more than doubled during 2001-2010 (WHO, 2009). Based on NASA and World Health Organization, severe water shortage will affect 4 billion people by 2050 worldwide.

Human beings need to be safe from harm (Maslow, 1968) and the Universal Declaration of Human Rights (1948) implicitly recognized that (Twigg, 2001). The need to determine drinking water quality for safe human consumption has been well recognized since 1855 when outbreaks of typhoid fever and cholera were related to water contaminated with faecal wastes (Moore, 1974). The WHO (1985) defines access to safe drinking water as provision of piped water to housing units or to public standpipes within 200 m of each household. It stipulated 40-50 litres per day per person as adequate (WHO, 1983), where water quality can be detected by the presence or absence of pathogenic organisms. The presence of faecal material in waters presents the most immediate hazard to health and if water contains more than 10 coliform 1 Escherichia Coli per 100 ml of water it will be considered contaminated and unsuitable for human consumption (WHO, 1983).

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Chemical assessment of drinking water is also important from the viewpoint of public health. It includes detection of heat (temperature), alkalinity, acidity, chlorine, calcium, sulphur, ferrous and electro-conductivity. The WHO (1984) did not recommend guideline values for water temperature since its control is usually impracticable. But, low water temperature would tend to decrease the efficiency of treatment processes including disinfection and may thus have a deleterious effect on drinking water quality and growth of microorganisms. For drinking water to be germ-free, it has to be disinfected by chlorine compounds, including chlorine gas, sodium hypochlorite, calcium hypochlorite and ferric chloride (FeCl₃), which are widely used. The recommended level of chlorine for drinking water is 250 mg/L (WHO, 1984), and it is widely used as a water disinfectant for community water supplies because of its comparatively low cost and ease of application.

Calcium recommended concentration in drinking water is 75-200 mg/L, while for ferrous it is 0.3 mg/L. Electro-Conductivity (EC) of ions indicates the ratio of total dissolved salts and reversely an increase in electro-conductivity means an increase in water salinity. The standard EC unit used by the Victorian Salinity Program and the Murray Darling Basin Commission is micro Siemens per centimetre (µS/cm) at 25°C where EC range (µS/cm) 0 – 800 µS/cm is good drinking water for humans (provided there is no organic pollution and not too much suspended clay material). The EC range (µS/cm) 800 - 2,500 can be consumed by humans although most would prefer water in the lower half of this range. The EC range (µS/cm) 2,500 - 10,000 is not recommended for human consumption, although water of up to 3,000 µS/cm could be drunk if nothing else was available.

Water alkalinity is useful since it acts as a buffer against changes in pH where its international standard is recommended in the range 6.5 – 8.5 (WHO, 1971). The alkalinity of water may be defined as its capacity to neutralize acid. Alkali substances in water include hydroxides or bases. They can be detected by their acrid taste. Moderate concentrations of alkalinity are desirable in most water supplies to balance the corrosive effects of acidity. Strongly alkaline Waters have an objectionable "soda" taste.

Phosphates and silicates are rarely found in natural supplies of water in significant concentrations. Compounds containing these ions may be used in a variety of water treatment processes. However, excessive quantities cause a number of problems. These ions are free in the water, but have their counterpart in cations such as calcium, magnesium and sodium or potassium.

The Pressure and Release Model can reduce the impact of a hazard (Blaikie et al., 1994 and Wisner et al., 2004). This model has become internationally accepted for explaining progression of vulnerability (risk accumulation) and progression to safety (risk reduction). The model emphasizes locally based action to reduce occurrence, frequency or strength of hazards. Also it identifies elements to withstand the impacts of hazards and safe conditions by all vulnerable people who have capacities to be nurtured and used to lessen the impacts of hazards. Also, it releases pressures that some processes and structures such as community based organizations may actually work to
lessen vulnerability. This paper adopts this model in an attempt to reduce health hazards relating to drinking water in Kas town (Figure 4).

**Kas Town Water**

Field observations and direct interviewing with local people, resident water engineers at Kas water stations and UNICEF water engineers and officers during 2008, and also data provided by Hunting Company on chemical analysis of underground water revealed high levels of chloride, alkalinity, salinity, calcium, ferrous elements and electro-conductivity in 23 wells. Calculations of the mean and the standard deviation were done for chemical properties (Table 2).

Kas town is classified as small town according to its population size of 103,556 persons (Sudan Census, 2010). It lies between 12°30' N and 24°47' E. And is bordered by Jebel Merra, Nyala, Idd el Firsan, Wadi Salih and Zalangi localities from the north, east, south, west and northwest respectively (Figure 1). Basement complex and metamorphic rocks form the underlying structure of Kas town (GRAS, 2005). Sedimentary rocks are the superficial deposits (Whiteman, 1971) as well as the prevalence of sand dunes over the surface of Darfur (Parry et al., 1981). The climate is hot and dry during most of the year with a mean temperature of 28°C during winter (November-January). Soil types include sandy, sandy clayey and clayey soils. Vegetation cover includes Acacia trees and rich savannah grasses.

Tribes of Kas town are Zaghawa, Fur, Tungur, Brti, Masaliet, Hausa, Rizaigat, Bani Halba and Chadian migrating tribes. People practice cultivation, animal keeping, trade and traditional industries. Rain-fed agriculture is near valleys, mountainous areas and sandy/clay plains. People cultivate sorghum, bulrush millet, ground nuts, broad beans, sesame and watermelons during the rainy season, and vegetables and citrus during winter. They also keep animals within their neighbourhoods where their number amounts to 154,500 heads (Veterinary Office, 2008). They move during the rainy season and stay around during winter depending on fodder and farming remnants. Traders are mostly involved in agro-animal products and similarly traditional industries producing shoes, bags, straw mats, cheese, etc.

**Water Production, Distribution and Consumption**

The estimated amount of underground water in Kas town is 35 million m³, distributed mostly within two major aquifers composed of gravel and sand (Hunting Company, 2008). Kas aquifers holding capacity is 8 million m³ with a mean thickness of 20 metres. Gumaiza aquifer holding capacity is 3 million m³ with a mean thickness of 15 metres (Figure 2). Both aquifers have general permeability of 5-7 metres/hour. The highest level of underground water is recorded at the confluence of Gandati and Garah valleys where 23 wells are dug. The valleys form the two main charging sources of water for these two aquifers, being enhanced by rainfalls between May and mid October, with an annual average of 500-900 mm, a peak in August and annual fluctuation of 25% (Meteorological Office, Kas, 2008).
Figure (1): Location and layout of Kas town.
Figure (2): Aquifers in Kas Town.
The fieldwork revealed that there are only 8 operating wells out of 23, and the average water production by well per hour is 10 \( \text{m}^3\), while average hourly pumping is 10 hours per pump (Kas Waters Authority, 2008). Based on that, the total daily production is calculated as follows:

<table>
<thead>
<tr>
<th>No. of wells</th>
<th>No. of operating wells</th>
<th>Daily production</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>8</td>
<td>800 ( \text{m}^3)</td>
</tr>
</tbody>
</table>

*Note: 1M\(^3\) = 1,000 litres*

The Jordanian Voluntary Authority established water networks of Kas town in 1988. The town grew and the population more than tripled (Population Office, Kas town, 2008). According to the fieldwork results, the majority of town’s population depends on water vendors while few have adequate piped water. UNICEF is providing and managing 58 water pumps in densely populated parts of the town with 250 persons holding capacity per pump (Kas Waters Authority, 2008). Interviews with water resident engineers in Kas town revealed that breaks, cross connections and pipe walls impaired the network’s full capacity for water distribution.

Kas Waters Authority (2008) estimated the total daily consumption of water by the population at 500 \( \text{m}^3\). However, the fieldwork estimated 2,000 \( \text{m}^3\) daily consumption, based on 20 litres (0.02 \( \text{m}^3\)) per person and population size of 103,556 persons. The difference is threefold between the two estimates. Fetching for daily water takes 2 hours, a duty done by women and children. The pricing of water is 100 SDG per tin (equals 4 USA gallons = 16 litres). This makes the average family of 6 persons (fieldwork, 2008) pays 22 SDG/ month compared with 15 SDG a family pays in Greater Khartoum ($1 = 2.33 SDG).

Animals estimated daily water consumption is 2,750 \( \text{m}^3\) (Table 1), exceeding human consumption by 750 \( \text{m}^3\). But, the fact that animals are staying away for some months of the year makes water surplus for people. Estimated daily water requirements for both human and animal consumption is 4,750 \( \text{m}^3\), apparently exceeding production.

**Table (1):** Animal daily, monthly and annual water consumption in Kas town (litres).

<table>
<thead>
<tr>
<th>Animal type</th>
<th>Number</th>
<th>Daily/head</th>
<th>Total daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camel</td>
<td>12,500</td>
<td>36</td>
<td>450,000</td>
</tr>
<tr>
<td>Cows</td>
<td>25,750</td>
<td>20</td>
<td>515,000</td>
</tr>
<tr>
<td>Goats</td>
<td>56,500</td>
<td>10</td>
<td>565,000</td>
</tr>
<tr>
<td>Sheep</td>
<td>44,250</td>
<td>10</td>
<td>442,500</td>
</tr>
<tr>
<td>Horses and donkeys</td>
<td>15,500</td>
<td>18</td>
<td>279,000</td>
</tr>
<tr>
<td>Total</td>
<td>154,500</td>
<td>94</td>
<td>2,751,000</td>
</tr>
</tbody>
</table>

*Note: calculations are based on data provided by Population Office, Veterinary office and Water Authority in Kas town (2008).*

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## Chemical Properties of Drinking Water

Chemical properties of drinking water are important enough to determine water suitability for human and animal consumption. Here, some results are available for Kas town (Table 2).

### Table (2): Chemical properties of drinking water in Kas town (1 mg/litre).

<table>
<thead>
<tr>
<th>Well No</th>
<th>Calcium</th>
<th>alkalinity</th>
<th>chloride</th>
<th>sulphur</th>
<th>Ferrous iron</th>
<th>Electroconductivity (µS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>169</td>
<td>73</td>
<td>38</td>
<td>19</td>
<td>0.1</td>
<td>140</td>
</tr>
<tr>
<td>3</td>
<td>19</td>
<td>42</td>
<td>16</td>
<td>13</td>
<td>0.8</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>94.5</td>
<td>11</td>
<td>17</td>
<td>0.3</td>
<td>240</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>47</td>
<td>23</td>
<td>-</td>
<td>0.7</td>
<td>78</td>
</tr>
<tr>
<td>8</td>
<td>240</td>
<td>530</td>
<td>500</td>
<td>-</td>
<td>-</td>
<td>1000</td>
</tr>
<tr>
<td>9</td>
<td>198</td>
<td>361</td>
<td>253</td>
<td>-</td>
<td>-</td>
<td>710</td>
</tr>
<tr>
<td>10</td>
<td>58</td>
<td>81</td>
<td>28</td>
<td>-</td>
<td>0.1</td>
<td>120</td>
</tr>
<tr>
<td>11</td>
<td>31</td>
<td>683</td>
<td>13</td>
<td>-</td>
<td>0.7</td>
<td>1200</td>
</tr>
<tr>
<td>12</td>
<td>39</td>
<td>155</td>
<td>59</td>
<td>-</td>
<td>0.2</td>
<td>200</td>
</tr>
<tr>
<td>14</td>
<td>35</td>
<td>85</td>
<td>38</td>
<td>-</td>
<td>0.1</td>
<td>200</td>
</tr>
<tr>
<td>15</td>
<td>62</td>
<td>263</td>
<td>62</td>
<td>-</td>
<td>0.5</td>
<td>490</td>
</tr>
<tr>
<td>20</td>
<td>166</td>
<td>208</td>
<td>41</td>
<td>-</td>
<td>0.3</td>
<td>480</td>
</tr>
<tr>
<td>23</td>
<td>70</td>
<td>1116</td>
<td>42</td>
<td>-</td>
<td>0.9</td>
<td>390</td>
</tr>
<tr>
<td>24</td>
<td>127</td>
<td>184</td>
<td>61</td>
<td>-</td>
<td>-</td>
<td>360</td>
</tr>
<tr>
<td>25</td>
<td>23</td>
<td>86</td>
<td>39</td>
<td>-</td>
<td>0.2</td>
<td>200</td>
</tr>
<tr>
<td>26</td>
<td>41</td>
<td>69</td>
<td>28</td>
<td>-</td>
<td>0.3</td>
<td>200</td>
</tr>
<tr>
<td>28</td>
<td>73</td>
<td>57</td>
<td>67</td>
<td>-</td>
<td>0.3</td>
<td>200</td>
</tr>
<tr>
<td>31</td>
<td>38</td>
<td>76</td>
<td>30</td>
<td>-</td>
<td>0.3</td>
<td>105</td>
</tr>
<tr>
<td>30</td>
<td>33</td>
<td>49</td>
<td>28</td>
<td>-</td>
<td>0.9</td>
<td>110</td>
</tr>
<tr>
<td>35</td>
<td>31</td>
<td>47</td>
<td>23</td>
<td>-</td>
<td>0.4</td>
<td>120</td>
</tr>
<tr>
<td>36</td>
<td>23</td>
<td>253</td>
<td>28</td>
<td>-</td>
<td>0.3</td>
<td>160</td>
</tr>
<tr>
<td>41</td>
<td>27</td>
<td>92</td>
<td>36</td>
<td>-</td>
<td>0.1</td>
<td>140</td>
</tr>
<tr>
<td>43</td>
<td>43</td>
<td>63</td>
<td>23</td>
<td>-</td>
<td>0.2</td>
<td>15</td>
</tr>
<tr>
<td>Σ=23 wells</td>
<td>ΣX=1573</td>
<td>ΣX=3715</td>
<td>ΣX=1489</td>
<td>ΣX=49</td>
<td>ΣX=0.77</td>
<td>ΣX=12235</td>
</tr>
<tr>
<td>Σx = 68.4</td>
<td>Σx = 161.52</td>
<td>Σx = 64.7</td>
<td>Σx = 16.3</td>
<td>Σx = 0.37</td>
<td>Σx = 531.9</td>
<td></td>
</tr>
<tr>
<td>std = 6.4</td>
<td>std = 7.0</td>
<td>std = 2.8</td>
<td>std = 5.4</td>
<td>std = 0.02</td>
<td>std = 23.12</td>
<td></td>
</tr>
</tbody>
</table>

For water temperature, underground water is generally clean and somewhat cool compared with surface water because when such water passes through strata, it tends to lose oxygen so as to dissolve organic matter and holds elements affordable for solution in water like ferrous and lose bacteria. Average concentration of calcium in drinking water of Kas town is 68.4 mg/L which is less than the lowest recommended limit of 75-200 mg/L. The value of the standard deviation is 6.4 mg/L, indicating wide differences in the levels of calcium concentration in water within the town, as the range is 7-240 mg/L. Alkalinity ranges between 42 and 683, with small standard deviation value of 7.0 and mean value of 161.5 while the world recommended level is 6.5 – 8.5 mg/L, which means highly exceeding the safe level.

Chlorine mean value is 64.73 mg/L which is less than the world recommended level of 250 mg/L, with standard deviation value of 2.8 indicating a high discrepancy within the water of the town. Sulphur level is recorded within three wells only giving a mean value of 16.3. Ferrous mean value is 0.37 almost equaling the world recommended level of 0.3 mg/L with standard deviation value of 0.02 indicating to closer values within the wells. However, the mean value for electro-conductivity (EC) is 531.9 (μS/cm) and the standard deviation is 23.12 indicating to uneven distribution within the wells and by so doing to the ratio of total dissolved salts which reversely increase with increasing electro-conductivity and consequently determining water salinity. EC range (μS/cm) 0 – 800 μS/cm is good drinking water for humans, provided there is no organic pollution and not too much suspended clay material.

**Vulnerability to Health Hazards Relating to Drinking Water**

This subject could be discussed within water shortage, water maldistribution and water chemical properties which are shown in figure (3).

1) **Health hazards relating to water shortage:**

Inadequate water supply, or water shortage, in Kas town subjects the population to water shortage diseases. The daily consumption of an individual is 20 litres, far below the recommended level by the WHO (1983) for an individual to remain healthy, as it stipulated 40-50 litres (0.04 - 0.05 m³) per day per person as adequate. Water shortage causes infectious diseases such as trachoma, skin infections, intestinal infections, diarrhoea, eye infections, as well as low personal hygiene and food insalination. Studies in USA and Sudan suggest ½ to ¾ bacilli dysentery being related to water shortage (Ciba, 1974).

Water washed diseases are caused by water scarcity where people cannot wash themselves, their clothes or home regularly. Trachoma for example, is the main cause of preventable blindness in the developing world, with four million sufferers, an estimated 500 million at risk and six million permanently blinded. Such diseases are common in areas that are hot, dry and dusty, such as Kas town. Trachoma is spread, especially among young children, by flies, fingers and clothing coming into contact with infected eyes, spreading the infection to other people’s eyes. The infection causes a sticky eye discharge with soreness and swelling of the eyelids. After repeated infections scarring of the inner eyelids occurs which can lead to trichiasis where the eyelashes turn inwards. These then rub on the eye, scarring the cornea and causing blindness.
Figure (3): Water health hazards and related diseases in Kas town.

Scabies occurs in areas where there is lack of water and people are unable to wash themselves, their clothes, bedspreads or houses regularly. It is caused by the scabies mite which infest the surface layer of the skin. The mite can spread from one person to another through personal contact. Scabies causes itchy sores and lesions mainly between the fingers, wrists, elbows, breasts and pubic areas. In younger sufferers more areas, including babies' feet and the head, can be infected. Because sufferers often scratch the sores and lesions they become prone to other infections.
2) Vulnerability relating to water maldistribution:

Waterborne diseases are caused by viruses, bacteria, helminthes, unicellular, leptospiral, Cyclopes and snail, which cause hepatitis, typhoid, gastroenteritis, giardias, dysentery, etc diseases associated with maldistribution of drinking water. Waterborne diseases are any illnesses caused by drinking water contaminated by human or animal faeces, which contain pathogenic microorganisms which are directly transmitted. Contaminated fresh water, used in the preparation of food, can be the source of foodborne diseases through consumption of the same microorganisms.

Because water distribution in Kas town is mostly depending on vendors as the fieldwork results revealed, studies worldwide linked between health hazards and vendors. The study of Alredaisy (1993) shows that, the presence of Escherichia Coli. by 14/100 ml, in Mayo area, in the Green Belt area of southern Khartoum, exceeds the limit of 10/100 ml documented by WHO (1983). This is because the main water pipe at the borehole is in close contact with earth contaminated by animal faeces. This is in addition to the lack of vendors’ personal hygiene and the use of filthy barrels. According to the WHO (2009), diarrheal diseases account for an estimated 4.1% of the total daily global burden of disease and are responsible for the deaths of 1.8 million people every year. It was estimated that 88% of that burden is attributable to unsafe water supply, sanitation and hygiene, and is mostly concentrated in children in developing countries. The Annual Health Statistics Report indicated the prevalence of typhoid, dysentery, gastro and diarrhoea in southern Darfur, including the study area (Ministry of Health, 2008).

Resident water engineers in Kas town (fieldwork, 2008) indicated that, due to breaks of cross connections and pipe walls, it is expected that physical and hydraulic problems can lead to the influx of contaminants across the water network. These external contamination events can act as a source of inoculums, introduce nutrients and sediments, or decrease disinfectant concentrations within the distribution system, resulting in a degradation of water quality. Even in the absence of external contamination, however, there are situations where water quality is degraded due to transformations that take place within piping, tanks, and premise plumbing. Decreases in disinfectant concentrations with travel time through the distribution system could be the result of an external contamination event or it could be due to disinfectant reactions with pipe walls and natural organic matter remaining after treatment. They further indicated that specific reactions might occur that introduce undesirable compounds or microbes into the distribution system. These reactions can occur either at the solid-liquid interface of the pipe wall or in solution. Obvious microbial examples include the growth of biofilms and detachment of these bacteria within distribution system and the proliferation of nitrifying organisms. Important chemical reactions include the leaching of toxic compounds from pipe materials, internal corrosion, scale formation and dissolution, and the decay of disinfectant residual that occurs over time as water moves through the distribution system.

3) Vulnerability relating to chemical properties of water:

In the absence of exact scientific information, scientists predict the likely adverse effects of chemicals in drinking water using human data from clinical reports and epidemiological studies.
and laboratory animal studies (Zaslow et al., 1996). Excess or deficit in the chemical property of water in Kas town indicated to vulnerability to some health hazards associated with each one. The results of this paper suggested that water temperature is normal, and at the safe levels recommended by the WHO, chlorine and calcium records are less than the recommended levels, while alkalinity highly exceeds the safe level, water salinity is good, provided there is no organic pollution and not too much suspended clay material.

Studies worldwide have closely referred many health hazards to inappropriate chemical properties of drinking water. Since underground water is generally cold if compared to surface water it is expected to influence taste since warm water tastes flat and inspired partly as a result of the decreased solubility of oxygen and carbon dioxide at elevated temperature. Cold water is generally more palatable. But, low temperature would tend to decrease the efficiency of treatment processes including disinfection and may thus have a deleterious effect on drinking water quality. Microorganism’s growth in water is influenced by temperature like in any other environment.

Excess chloride causes undesired teeth colours, while less chloride subject drinking water to infection by microorganisms. Therefore chlorine is widely used as a disinfectant. Calcium affects blood channels and kidney and lead to hypertension, rickets, kidney diseases and cadmium toxicity is due to calcium and magnesium dissolved in water. Highly mineralized alkaline waters cause excessive drying of the skin due to the fact that they tend to remove normal skin oils. Ferrous iron level in Kas town imparts a bad metallic taste. It causes rust stains in toilets, plumbing fixtures, tableware and laundry. As little as 0.1 ppm of iron can cause these problems. Iron can exist in water in one of two forms or both. Treatment depends on the form of iron present. Waters containing "ferrous iron" are clear and colourless when drawn. Exposure to air converts ferrous iron into the insoluble, reddish brown "ferric iron". Iron can also contribute to hardness. These elements form scale in piping, water heaters, and dishwashers causing expensive repairs. Ferrous oxides cause abdominal trouble, clumsiness convulsion, extensor and brain damage and influences neuron cells and accumulate in bones and in blood, liver, pancreas and kidneys; sulphur oxides affect lining of respiratory tract (Meade et al., 1988).

Water salinity level is good in Kas town but, biological contamination and suspended clayey material discard its value. Scientists report that over 150 degenerative diseases are caused by high acid levels in the body. The pH scale ranges from 0 to 14, with 0 being extremely acidic, 14 being extremely alkaline and 7 being neutral. Body fluids range between 4.5 and 7.5 pH (blood must maintain 7.35 to 7.45 pH). A one point drop on the pH scale is 10 times more acidic. In order for the body to remain healthy, it keeps a delicate and precise balance of blood pH at 7.365, which is slightly alkaline. High acid levels contribute or cause directly, numerous health problems. Acid systems can’t use calcium effectively. They can’t maintain proper blood oxygen levels and cancer can only develop in an oxygen poor, acidic environment. Acidic blood can’t circulate properly creating extra strain on the heart. It adversely affects the digestive and lymphatic systems.
Gama' (1999) indicated to shortage of iodine in drinking water in Kas town which causes goitre gland diseases. Prevalence of iodine disorders among school children of Delhi showed that IDD continues to be prevalent in mild endemic proportions. Compared to the results of previous surveys, the IDD rate has declined in the last few years. However, it continues to be an important public health problem in Delhi (Pandav et al., 1997). A preliminary investigation of the iodine content of salt on sale in Western Kenya showed that iodine deficiency disorders are known to be a potential problem for large numbers of people living in the highland areas of the West (Alnwick, 1988). The fieldwork also detected contact with gasoline, as pumps were positioned directly over the well cover, thereby increasing the possibility of contamination.

Conclusion

Aquifer depletion is a new world problem. Water tables are falling in large portions of continents from over-pumping of groundwater. Kas town is not an exception; its population is vulnerable to health hazards associated with water shortage, maldistribution and chemical properties. High rates of population growth and the subsequent increasing demand for water and the low priority given to water treatment, together with climate variability and droughts, increased the pressure on water resources in this town and may lead to conflicts over water in the future.

Based on Pressure and Release Model, developing water resource capacity in Kas town can reduce vulnerability to water related diseases through community involvement, introduction of hygiene education and by enhancing community groups of women and youth, rainwater harvesting and reducing the number of animals (Figure 4).

The control of waterborne diseases requires a safe water source of high quality and with enough water for the practice of general water hygiene, which will ensure that water stays safe. Also, the control of water-washed diseases depends on easy access to large quantities of water and the motivation to use more water for personal hygiene, whereas the quality of the water used is less important. Similarly, the control of water-based diseases depends on elimination of contact with the infected water source. The availability of water is essential for hygiene and, naturally, an easily accessible water source facilitates the practice. But to ensure that water hygiene is practiced daily, the water source must be reliable both in quantity and quality throughout the year. An improved water source can be contaminated if poorly maintained.

The motivation of the community to maintain and protect their water source is, therefore, of critical importance to ensure a sustainable reduction in waterborne diseases. Strengthening rainwater harvesting networks, when there are 500-900 mm of annual rainfall, will facilitate the promotion of knowledge and build a database of practice and endeavours to disseminate such understanding. Water harvesting can be done by households and official authority. Provision of small water tanks, using houses' roofs and huge trees storage will provide drinking water during the rainy season and reserve the rest for the dry season. Official authority can gather water in small valleys to enhance underground water supply, as well as improving chemical properties for better and more reliable consumption.
Figure (4): Developing water consumption capacity to reduce diseases related to water quality and quantity in Kas town.

Introduction of education for sustainable development (ESD) into schools curricula, students’ activities, mass media and youth clubs will inform the community on rational water use. Sustainability at any level requires the involvement of local level communities. Involving men and women for sustainability will ensure sustained use of the water resources in Kas town. Women are an important target group, as they play a significant role in rural family life and have a prominent role in improving the hygiene within the family. Planning and implementation of hygiene education is essential to ensure community participation. Hygiene education should aim to actively involve the entire community.
Through increased knowledge and awareness the community can be motivated to take better care of their water source and practice better water hygiene when collecting and storing water, and use more water for hygienic purposes. School teachers should be trained to promote hygiene education, particularly in primary schools. Further to reinforce the practice of better hygienic behaviours, all schools should have, and encourage the use of hygienic latrines with hand-washing facilities close by. Drinking water should be safely stored and refuse properly disposed. Finally hygiene education should also be an integral part of the training of all personnel involved in the water and sanitation program; the extension worker, the drilling crew, the pump mechanic, the caretaker and the driver. They all have a unique chance to teach hygiene education when they are back in their communities.

Changing the composition of the herd by shifting to animals with low water consumption, may be sheep, goats, and camels, excluding cattle and changing the society’s view towards animal quality rather than quantity will relieve pressure on water resources and provide additional water for people. This can be enhanced by construction and maintenance of rainwater reservoirs in the town’s neighbourhood. The follow-up of this proposed model is an integral part of the strategy for reducing health hazards relating to drinking water in Kas town. Above all, working towards social and political stability in Darfur will benefit from formulating national water strategies in Sudan. Those strategies have to consider maximizing rational use of water resources in situations of changing societies and global warming.

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