Sanitary survey of drinking water sources in Shendi locality-River Nile state-Sudan

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ملخص البحث

أجريت هذه الدراسة في محلية شندي بغرض تقييم جودة مياه الشرب بالمحلية واختبار ارتباطها بالمحددات والمشاكل الصحية الناتجة علي المستهلكين لهذه المياه وهي من نوع الدراسة التحليلية المقطعية الغير تدخليه القائمة علي المجتمع.

تتكون مجتمعات هذه الدراسة من مصادر مياه الشرب في كل مدن وقري المحلية. تم اخذ عينات عدلية(Random samples). جمعت البيانات في هذه الدراسة باستخدام المسح صحي لمصادر المياه والكشف طبي علي العمال المشغلين لمحطات المياه الداخلين في العينة و التحليل البكتيري لعينات المصادر عن طريق الترشيح الغشائي (Membrane filtration)والتحليل الكيمائي. و تم تحليل البيانات باستخدام الحاسوب الالي (كمبيوتر) باستخدام برنامج الحزم الإحصائية للعلوم الاجتماعية (SPSS). وتوصلت الدراسة الأتي:-

- أن أكثر من ثلث المصادر في قرى المحلية ملوثة بالبكتريا المؤشرة indicator bacteriaعلى وجود الكائنات الممرضة وغير صالحة للاستخدام الآدمي إلا أنها ما تزال مستخدمة كمصادر أساسية للمواطنين بتلك الأرياف.
- أن الآبار السطحية مازالت مستخدمة في بعض القرى بالمحلية علي الرغم من إعلان عدم صلاحيتها ووقف استخدامها وكل هذه الآبار السطحية المستخدمة بقري المحلية وجدت ملوثة بالجراثيم الممرضة الناتجة عن الفضلات الآدمية أو الحيوانات.

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Abstract:

This study was designed as community based observational analytical cross-sectional study in the Shendi, which is one of the River Nile state localities, Sudan to assess the quality of drinking water, its associated health risk, impact and consequences to consumers. The study involved all the population, and drinking water source in the towns and the villages.

Proportional stratified sampling allocation was followed to select the sample from the water source and the community.

Data were collected through;

- In structural interview Sanitary and medical surveys
- of the households and source of drinking water.
- Microbiological(based on the membrane filtration test)and chemical analysis of drinking water

A selected number of physicochemical parameters were measured in order to establish whether or not the problem of chemical contaminations exists for water sources. (SPSS) version 11.5 was used for data analysis.The most importance results were:

- Shallow wells are still used beside the other sources in some villages in Shendi. All the selected shallow wells and one third of the drinking water sources were contaminated, and were not conforming to the criteria and quality standards of safe and wholesome water as defined by WHO or the Sudan (SSMO).
- Based on the results and conclusion of this study, some recommendation emerged to mitigate the problems related to drinking water.

Introduction:

Clean water is essential to human life. In many parts of the world, it is in short supply.

Without water, life cannot be sustained beyond a few days and the lack of access to adequate water supplies leads to the spread of disease.

This natural resource is becoming scarcer in certain places, and its availability is a major social and economic concern. Currently, about

1 billion people around the world routinely drink unhealthy water. Most countries accepted the goal of halving by 2015 the number of people worldwide who do not have access to safe water and sanitation during the (2003) G8 Evian summit [WHO, (2000) & Nathanson Jerry. A., (2004)] Even if this difficult goal is met, it will still leave more than an estimated half a billion people without access to safe drinking water supplies and over 1 billion without access to adequate sanitation facilities. Poor water quality and bad sanitation are deadly; some 5 million deaths a year are caused by polluted drinking water.

In the developing world, 90% of all wastewater still goes untreated into lo-

cal rivers and streams. Some 50 countries, with roughly a third of the world's population, also suffer from medium or high water stress, and 17 of these extract more water annually than is recharged through their natural water cycles [Wiley John&Sons, (1993) & *Yahoo* (*April* 19, 2006)]. The strain affects surface freshwater bodies like rivers and lakes, but it also degrades groundwater resources.

UNESCO's World Water Development Report (WWDR, (2003)) from its World Water Assessment Program indicates that, in the next 20 years, the quantity of water available to everyone is predicted to decrease by 30%. 40% of the world's inhabitants currently have insufficient fresh water for minimal hygiene

In (2000), 1.1 billion people lacked access to improved water sources. 86% of these were in rural areas.

Millennium declaration set out principles and values that should govern international relations in 21st century the summit established goals and targets to be reached by (2015) in seven areas, including: to do more to reduce lack of access to clean water, and environmental degradation (WHO, (2003)).

"The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses" - General Comment No. 15 (2002): The Right to Water (Guy Howard, 2003).

The latest dietary reference intake report by the United States National Research Council in general recommended (including food sources): 2.7 litres of water total for women and 3.7 litres for men. [KhopkarS.M,1993&www.unep.org/vital water/01.htm March26, 2006] Also noted is that normally, about 20 percent of water intake comes from food, while the rest comes from drinking water and beverages.

Norms for quantities of water to be supplied have been proposed for certain specific conditions. For instance the SPHERE project sets out 15 litres of water used per capita per day as being a key indicator in meeting minimum standards for disaster relief (SPHERE, 1998). In their guidance manual prepared for the Department for International Development (UK), WELL (1998) suggested that a minimum criterion for water supply should be 20 litres per capita per day, whilst noting the importance of reducing distance and encouraging household connection. A similar figure has been suggested by other researchers (Carter et al., 1997). Gleick (1996) suggested that the international community adopt a figure of 50 litres per capita per day as a basic water requirement for domestic water supply.

In the WHO Guidelines for Drinking-Water Quality, Guideline Values for chemical contaminants are based on the assumption of a 60 kg

adult consuming 2 litres per day from drinking water, which would be equivalent to 3 litres per capita per day including food consumption (if the ratio cited by Kleiner were applied). Where specific guidance is needed for vulnerable populations, a figure of 1 litre per day for a 10kg child or 0.75 litre per day for a 5kg child are used (WHO, 1993).

Over 90 (percent) of the Sudan's area lies within climatic zone where the total annual evaporation exceeds the total annual rainfall, it is also demonstrated that largest portion of the country's surface water sources are fed from catchments located outside the Sudan's boundaries. It has been estimated that over 35 billion cubic meters of the Nile water is annually lost at the swamps of its upper reaches.

Streams contribute roughly about 7 billion cubic meters to the country's annual water supply.

Sudan's ground water supply could be of an order of magnitude equaling over 2 billion cubic meters as annual recharging and exceeding 500 billion cubic meters as stored reserve (WHO, 2002 and National Council for Research (NCR), 1982).

There are numerous problems, however, hindering the maximum utilization of these sources, the basic common is:

- Absence of a unified plan for the meteorological, hydrological and hydro geological gauging of these resources.
- In adequacy and diversity in the available networks and in the method of measuring these parameters.
- In adequacy and diversity in the method of compilation and presentation of the data obtained from the present networks.
- Lack of coordination and systematic exchange of information and lacks of communication between the bodies dealing with these parameters, and the bodies that utilize the country's water resources.
- Lack of organized systemic plan for water technology transfer from highly developed worldwide sources to the different corresponding sectors inside the country.

Humans can also cause surface water to be "lost" (i.e. become unusable) through pollution.

Material and methods

Type of the study:

This observational, analytical study was designed as community based cross-sectional study in the locality of Shendi, to assess the quality of drinking water and its health risk. To identify all possible hazards associated with drinking-water and hazard would have an adverse public health consequence.

Study area: Shendi locality

Shendi locality is one of the River Nile state localities. It is bounded by Elddamer locality northern

of the River Nile State, Khartoum state to the north, River Nile to the west and Gadarif state to the east.

Geographically it lies between line 36^0east to 31^0west longitudinal and line 19^0 north to line 15^0 south latitudinal in the arid zone of Sudan .According to Sudan Meteorological Authority at Shendi Station the climatic condition of the area is arid and semiarid with very little or rare rainfall, which falls during summer season.

In Shendi town there are about 16 artesian wells with average mean depth 106 to 441 meters representing the sources for drinking water in the Shendi town managed by urban (municipal) water management authority.

The Rural areas of the Shendi locality are composed of about 96 villages, 63 of these are at southern side of the locality. The sources for drinking water in these villages are various. There are about 54 artesian wells; 29 of which are at the north of the locality, with mean depth about 140 – 1001m and average productivity of 216 to 8000 gallons per hour for each one. And 25 of these boreholes at northern of the locality, with mean depth about 99 – 540 and average productivity of about 880 to 9600 gallons per hour for each borehole. 28 Nile stations proposed to have slow sand filters but all of these Nile stations are without filter beds .The average productivity for each station is about 65 to 100 cubic meters/ hour (see appendix 2 - 4). There are 16 hand pump wells 13 of these types are at northern and 3 at southern of the Shendi locality (see appendix 2-5).10 Hafris supply water all over the year, with average productivity of about 30000 cubic meters / hour for each Hafir (see appendix 2-6), and a lot numbers of rain season traditional Hafirs, and a lot numbers of shallow wells with various depth few of them still in use. These shallow wells were closed by the governorate authorities, declared as unsuitable and prohibited for human consumption because they lack hygienic precautions and exposed to contamination from man and animals excreta. Also there is only one reservoir constructed on El Awataib valley in 2004.

Study population and sampling technique:

The study involved all the towns and the villages, the population, and their drinking water sources in the locality of Shendi.

System of proportional stratified sampling allocation was followed to select the sample from the water source and the community. Each water source considered as separate stratum and therefore we have four strata (Hafir, Borehole, Nile station and Hand pump wells) the required sample size was determined using the formula :

$$n = \{ 2\sigma^2 (Z_\theta + Zp)^2 \} / d^2$$

Where $\sigma = 7.14$

Z_θ = the value of standard normal variable corresponding to 95% confidence

Results and results analysis

Table (1) Types of the selected sources of drinking water in Shendi locality/

Typeof the source	Frequency	Percentage
Shallow well	3	6.3
Deep borehole	27	56.3
Nile station	11	22.9
Hand pump well	3	6.3
Hafir	4	8.3
Total	48	100.0

River Nile state Sudan 2006

About 48 drinking water sources were randomly selected from the whole of Shendi locality.

Table (2) Average consumption of water for the selected households:

Neighbor-hood	Average water consumptioL/ person/day	Fre-quency	%
Urban	<2	38	42.2
	2 – 5	41	45.6
	6 – 10	11	12.2
	Total	90	100
Rural	< 2	99	43.0
	2 – 5	117	50.9
	6 – 10	14	06.1
	Total	230	100

Great numbers of the families in the locality were estimated that they consume less than 2 litres per day per person in average. Consumption of drinking water was found to be more among the families in urban areas, than the families in rural areas.

Table (3) Presence of Sanitary certificate for the selected sources of drinking water:

Sanitary certificate of the source	Frequency	Percent
Present	2	4.2
Not present	46	95.8
Total	48	100.0

95.8% of the selected sources lacked sanitary certificate. And it is doubtful whether they were recommended as fit for human conception at the beginning of consumption, due to the absence of sanitary certificate.

Table (4) Presence of a fence for the selected sources of drinking water:

Source fenced	Frequency	Percent
Available	14	29.2
Not available	34	70.8
Total	48	100.0

70.8% of the sources were not fenced and exposed to contamination, from human and animal excreta and manure. Also it was observed nearly all of sources were dirty and surrounded with human excreta and animals manure or/ and garbage. This condition indicates the carelessness and lacking of awareness of those responsible for these sources.

Table (5) Health status of the operators for the selected sources of water:

Source operator suffering from	Frequency	Percent
Notexplaining(many problems)	16	33.2
Enteritis	10	20.8
Abdominal pain	7	14.6
Respiratory infection	5	10.4
Others non infectious diseases	38	79.2
Did not answer (no response)	10	20.8
Total	48	100.0

All the operators of the drinking water sources were suffering from infectious and non infectious diseases. This state may make the operators as risk factors to disseminate these infectious agents to the consumers when contact with the water of these sources. None of the operator was having medical certificate.

Table (6) Bacterial contamination among the different selected sources of drinking water:

Type of the source	Contamination with E.coli (thermotorerant coliform)		
	Yes	No	Total
Shallow well	2 (66.67%)	1 (43.33%)	3 (100%)
Deep Borehole	5 (18.51%)	22(81.49%)	27 (100%)
Nile station	1 (9.09%)	10 (90.91%)	11 (100%)
Handpump	3 (100.00%)	0 (00.00%)	3 (100%)
Hafir	4 (100.00)	0 (00.00%)	4 (100%)
Total	15 (31.25%)	33 (84.75%)	48 (100%)

P-value<0.001

Contamination of the drinking water with E.coli (thermotorerant coliform) was very significantly associated with the types of the source. Hafirs counted the highest numbers of E.coli colonies .Hand pump and Shallow wells also showed high contamination with E.coli, Deep Borehole and Nile station were less contaminated with E.coli. All the selected Hafirs and Hand pump wells were contaminated with E.coli. Deep wells count the lowest colony numbers of E.coli and all bacteria.

Discussion

Water is of paramount importance, since it is needed to sustain life to existence and all of the human activities require fresh water. Table (1) showed that: Water resources in Shendi locality includes; Deep wells, Nile stations, Hafirs, Shallow wells and Hand pump wells. Water demand already exceeds supply in the locality as in many parts of the world. As, BBC News, in March 17, 2003 reported; The Middle East region has only 1% of the world's available fresh water, which is shared among 5% of the world's population. Thus, in this region, water is an important strategic resource. According to a report by the Arab League, two-thirds of Arab countries have less than 1,000 cubic meters (35,000 ft^3) of water per person per year available, which is considered the poverty limit.

It was not accurately clear how much is the water intake per person per year in the study area, but table (2) indicates: that great number of the families in the locality estimated to be consuming less than 2 litres per day per person in average. These quantities were less than the recommended in the latest dietary reference intake reported by the United States National Research Council, which in general recommended: 2.7 litres of water as total for women and 3.7 litres for men. It is dangerous to drink too little of water in warm humid climate like Shendi.

Despite of extensive debate about the relative importance of water quantity, water quality, sanitation and hygiene in protecting and improving health, international guidelines or norms for minimum water quantities, that domestic water supplies should provide remain largely lacking(Cairn cross, 1990; Esrey et al., 1985; Esrey et al., 1991). For instance, whilst the Millennium Declaration Goals include a target to 'halve the proportion of people who are unable to reach or to afford safe drinking water by 2015' (UN, 2000) it does not specify in what quantity such water should be supplied.

The most dominant type of drinking water source was found to be the deep wells (see table (1)). This type of water source, although costly to construct and operates, it is in many ways the ideal supply and most practical means of providing water to small communities, like those in the city and rural area of Shendi locality.

Deep wells water is likely to be of certain yield even during dry season. Also it is likely to be free from pathogenic agents, and less subjected to contamination, and usually requires no treatment.

The second common type of water source in Shendi locality is Nile stations were supposed to be based on slow sand filters which is an old fashioned, but not out dated method of water treatment. As Dr. Bark, (2002) stated that slow sand filtration is still the chosen method of water purification in a number of highly industrialized cities in U.S. and Europe. But

these stations in Shendi lacked the most importance criteria of slow sand filter. They consist of one or two sedimentation tanks only. When the sedimentation is properly done, it would help to reduce suspended solids and, could remove significant numbers of harmful organisms from polluted water. Actually water didn't take any time in these tanks (retention time is negligible) of the Nile stations. Water is drawn from the river to the sedimentation tanks of these stations and distributed directly to consumers without treatment. Most of the sedimentation tanks of these stations were open and some time the consumers used to take their water directly from these tanks. Like the other sources all the Nile stations were not fenced (see table (4)) and were not subjected to any sanitary protection. They are prone to contamination from human and animal sources. As Colleen, WHO guideline (2002) and Burrows *etal* (1969) mentioned, such water is never safe for human consumption unless subjected to sanitary protection and purification before use.

Shallow wells are still used beside the other sources in some of the selected villages in Shendi, although they are neither admitted as declared by the governorate authority nor being used for human).

All the selected shallow wells were liable to pollution from neighboring sources of contamination such as latrines. It is known that, sanitary quality of the shallow wells water is likely to be poor and yield limited quantities of water with fluctuation.

Only one of the three selected shallow wells was having a parapet and these types of water source had neither platform nor drain. These wells were not closed yet and bulk of pollution was found to be introduced into the well directly through these open tops. In addition that when ropes and buckets from individual homes were found to be used for drawing supply. All these wells were not conforming to the criteria and quality standards of safe and wholesome water.

Also Hand pump wells and Hafirs were found to be used as sources of drinking water in rural areas of the locality.

Hafir is an open excavated pond started very early in Sudan where people used to dig small ponds in the natural depression to reserve water for the dry period. According to Dr. Adams in his book Nubia, the Cerridor to Africa (1948); Hafirs in Shendi locality were constructed in an ancient period since the the age of king Spelta, the first king who converted the capital of Meroitic kingdom to Bajrawiya in 550B.C.

In general as mentioned by WHO guide (1997); four problems are faced which affect the efficiency of serves reservoirs (including Hafirs); evaporation, silting and miss-use. Considering the last (miss-use) in Shendi, hafirs were found to be used for washing

clothes, watering cattle, human, cooking pots, children swimming and used for regular defecation around the edges which might be washed into the body of Hafirs at next rains or drains.

Generally as surface water supplies are all subject to continuous or intermittent pollution and must be treated to make them safe to drink. Hafirs in the Shendi locality go with this general fact and was found to be subject to unlimited possibilities of contamination and are highly dangerous, as a source for drinking water.

Only 4.2% from the whole of selected source were had sanitary certificates, which confirm that they were fit for human consumption at the beginning of consumption (see table, 3). Neither the communities, nor the health authority aware on health licensing of the drinking water sources, or medical fit for their operators.

More than two thirds (⅔) of the selected sources in Shendi locality were not fenced (see table, 4). Fencing the area around sources is the first line of defense which prevents pollution activities that may be a source of contamination and infection with water borne diseases, especially from the surface water. The consumers were not tensions about this situation, because they have no responsibility toward these sources. And also may be due to illiteracy and / or lack of awareness about these dangerous.

As in Hafirs and Nile stations most of the drinking water sources (about 93%) were found to be dirty and surrounded with human excrete and animals manure and/or garbage due to lack the fence. Added to the above risks no one of the operators of these sources is licensed medically to work. This situation may be due to illiteracy and lack of awareness, about importance of water sanitation or/and the absence of health inspection and community responsibility to supervision their sources. All the operators except 33.2% were suffering from either infectious disease (and might disseminate these disease to consumers through water), or non infectious diseases which might decrease their hourly productivity (see table,5).

Considering the above conditions for sources of water in the Shendi locality; it is hypothesized that, most of the selected sources of water were found to be not satisfying the quantity and quality criteria for potable drinking water as determined by WHO and the Sudan standards (SSMO, 2002).

Conclusions

The provision of an adequate supply of safe drinking water in Shendi is seem to be influenced by the general defects in the overall system of the services and of the primary health care. It would therefore be illogical to expect any substantial drinking water handling improvement without reconstructing PHC, removing its constraining conditions and empower its system.

Primary health care (PHC) practi-

tioners and its units were not involved in supporting and implementing water supply care services in Shendi. Drinking water projects lie outside the scope of the health sector, without or with very poor coordination especially during epidemics.

Most families in Shendi locality estimate that they consume less than 2 litres per day per person in average due to lack of the water. Water demand already exceeds supply in the locality as in many parts of the world.

Shallow wells are still used beside the other sources in some of the selected villages in Shendi. All the selected shallow wells were liable to pollution by neighboring sources of contamination such as latrines. All of these wells were not conforming to the criteria and quality standards of safe and wholesome water as defined by WHO or the Sudan (SSMO, 2002).

5- Hafirs in the Shendi locality were found to be subject to unlimited possibilities of contamination and are highly dangerous, as a source for drinking water.

Operators of the sources had not medical fitness certificates and about one third of them was suffering from either infectious disease (and might disseminate these diseases to consumers through water) or non infectious diseases which might decrease their hourly productivity & hence decreased water quantity.

Most of the selected sources of water were found to be not satisfying the quantity and quality criteria for potable drinking water as determined by WHO and the Sudan standards (SSMO, 2002).

Recommendations

1-Based on the results discussion and conclusion of this study the following recommendations are proposed to help in an improvement sources of drinking water management and which likely to involve consumers in preparing and using safe water at the household level, which will facilitate the ultimate goal of providing all of the Shendi's population with community piped water that is accessible, safe and affordable:

2- Assessment of the overall system of the health care; to improve its organizational capacity, in Shendi's locality in order to deliver primary health care components including safe drinking water supply. Good systems and processes in primary care are essential for better management of water sources and reduction of lifestyle risk factors.

3- Primary care practitioners (especially public health officers & sanitarian oversees), and agencies (including public health units) should be involved in supporting, implementing water supply and supervision, its handling in an integral

to the others primary health care (PHC) components in Shendi. Providing safe drinking water requires an integrated multisectoral development approach, establishing active partnerships between communities and water's providers and other sectors.

4- The state ministry of health, Shendi locality & Shendi University should have integrated health and hygiene education programmes to; modifying lifestyle risk behaviours, and strengthen community awareness, and participation in improvement the drinking water quality and availability, and in, excreta disposal and the general hygiene to reduce faecal–oral disease transmission in Shendi.

The governorate authority should give top priority to reduce lack of access to clean water, through adopting the Millennium Declaration Goals of the UN, (2000) which target to 'halve the proportion of people who are unable to reach or to afford safe drinking water by 2015. And integrate sanitation into water resources management strategies.

Shendi locality should adopt the concepts of healthy cities and healthy villages. An emphasis should be paid to establish effective and adequate water supply and environmental sanitation system for sustainable health within community based initiative (CBI) projects, to ensure its sustainability, through community ownership of these services.

Establishment of monitoring system, and activates the regulations responsible for health inspection and community responsibility, towards supervision their drinking water sources, and water handling; to control and grantee safe drinking water.

The local authority must prohibit by appropriate legislation the use of contaminated sources (e.g., All the Shallow wells should be closed by concrete) and have to close them immediately.

9- The drinking water providers have to consider physical appearance of drinking water that also pleasing and satisfactory to consumers to protect the use of alternative sources which may be poor and contaminated.

Appointment of workers should keep the catchments area of water especially surface water fenced, clear of garbage and free from human or animal intrusion, to protect these sources against impurities.

The rural drinking water's provider authority should improve the Nile stations water to be based on slow sand filter and increasing their treatment efficiency.

The locality health authority should have routine inspection for water sources and activated their regulations to control; over polluting ac-

tivities in the area of drinking water sources, such as dumping of hazardous substances, agricultural use of fertilizers and pesticides and the recreational activities.

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