Sanitation Risk point assessment at schools in Khartoum State, Sharg Elneel Locality (Elhaj yousif administration unit)

By:

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Associate Professor

Faculty of Engineering University of Khartoum

2010
Dedication

To my father and mother

To my wife, to my son

To the Environmentalist working to stop Environmental health crisis

Abdelhamid
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<td>Silver</td>
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<td>Cd</td>
<td>cadmium</td>
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<td>E. coli</td>
<td>Escherichia- Coli</td>
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<td>g/kg</td>
<td>Gram/Kilo gram</td>
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<td>Hg</td>
<td>mercury</td>
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<td>HDPE</td>
<td>high density polyethylene</td>
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<td>IRC</td>
<td>International Water and Sanitation Centre</td>
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<td>Li</td>
<td>Lithium</td>
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<td>MDGs</td>
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<tr>
<td>MF</td>
<td>Membrane Filtration Methods</td>
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<td>mg/litre</td>
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<td>NTU</td>
<td>Nephelometric Turbidity Unit</td>
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<td>Pb</td>
<td>Lead</td>
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<tr>
<td>PH</td>
<td>Hydrogen Ion Concentration</td>
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<td>SPSS</td>
<td>Statistical Package for the Social Sciences</td>
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<td>TCU</td>
<td>True Colour units</td>
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<td>UN</td>
<td>United Nations</td>
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<td>UNDP</td>
<td>United Nations Development program</td>
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<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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<td>UTIs</td>
<td>Urinary Tract Infections</td>
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<td>VIP</td>
<td>Ventilated improved pit latrine</td>
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<td>WASH</td>
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Abstract

The study conducted at Elhaj Yousif administrative area, Sharg Elneel locality, Khartoum State. A descriptive study conducted in (30) Basic and Higher secondary schools (governmental schools) selected using stratified random sampling out of the total schools in the study area.

Objectives:
The study aims to assess the schools sanitation facilities and the impact on schools pupils /students health through identifying and assessing the drinking water quality risk point at schools, determining the availability, types/function and use of the sanitation / latrines at schools and assessing the awareness and solid waste management practices at schools.

Materials and Methods
A descriptive study conducted in 30 schools out of 64 schools in the study area, including Basic and Higher secondary schools (governmental schools) in the study area, using the flowing materials and methods:
The study was done using three closed-ended questionnaires, interviewed among Schools stakeholders, teachers and observations. Physical, Chemical and bacteriological tests were done for drinking water samples.

The questionnaires contained questions on drinking water availability, types of sources, storage vessels and cups used for Teachers and Pupils/students drinking. Also including questions on sanitation and Excreta disposal facilities at schools, how many, cleanings and healthy and safety use, also school waste management and disposal practices.

The data collection was done in the last week of January and extending into the third week of February 2009.
Data entry and Data analysis were done using SPSS software.

The study analysis aimed to assess the Availability and Usage of infrastructures in schools regarding Water and Sanitation. Further, it also tried to explore the solid waste management practices.

The study findings showed that 80% of the schools are with drinking water sources and 53.3% of the schools with water supply all the day, 70.5% of the schools with piped water supply. For drinking water storage 56.75% of the schools using Zeers (Clay Jar) for drinking water storage and the others using Barrels, or both Zeers and barrels, these are traditional or made of plastic or metal vessels. Bacteriological water quality tests indicated presence of Thermo tolerant and E.coli in the tested samples. Chemical and physical water quality is acceptable. School student’s using public Ladles/cups with handle for drinking water from the storage vessels. 96% of the schools have toilets. The schools students (boys / girls) and teachers / staff using clean toilets and easy to open and lock. 60% of the schools practice the municipal solid waste management. Water and sanitation and hygiene promotion is part of the general education curriculum. Most of the teachers were trained on hygiene promotion and safety.

**Recommendations:** The flowing recommendations are drawn

To Scale up schools drinking water availability and quality, improve the schools sanitation status: availability, suitable types and functioning, additional numbers of toilets needed with proper establishment and maintenance. In addition, to involve all the schools in the municipal solid waste management system with attention to the waste collection and storage in schools and Strengthen of schools partnership and community involvement in schools water and sanitation programs.
مستقبل الدراسة

أجريت هذه الدراسة بمنطقة الحاج يوسف الإدارية، محلية شرق النيل، ولاية الخرطوم. دراسة وصفية تم إجراها في (30) مدرسة أساس وثانوي (مدارس حكومية، بينين و بينات) تم اختيارها باستخدام الاختيار العشوائي المنظم.

أهداف الدراسة: هدف الدراسة هو تقييم وسائل و خدمات الأصحاح في المدارس و تأثير ذلك على صحة التلاميذ والطلاب من خلال تقييم توفر و جودة مياه الشرب بالمدارس، تقييم توفر و أنواع وسائل الاحصاح مع تقييم عملها و استخداماتها و تقييم الممارسات و تطبيق و التخلص من النفايات الصلبة بالدارس.

طرق ووسائل إجراء الدراسة: تم إجراء الدراسة باستخدام (3) أنواع من استبيانات و تجمع البيانات من خلال استبانة مدراء المدارس و المعلمين مع إجراء بعض الملاحظات، وكذلك تم إجراء تحليل كيميائي و بكتيري لعينات من مياه الشرب.

تم جمع البيانات أنداء من الأسبوع الأخير من شهر يناير إلى الأسبوع الثالث من شهر فبراير 2009.

SPSS

النتائج: أوضحت الدراسة أن 80% من المدارس تقع في مناطق بها مصادر للمياه، 53.3% من المدارس توفر فيها المياه للاستخدامات المختلفة طوال اليوم و 70.5% من المدارس مصدر الماء فيها الشبكة العامة للمياه. 56.75% من المدارس تستخد باستخدام الايران، أخرى تستخدم البراميل أو الزيارات والماء من خلال أجهزة مياه الشرب أو البراميل معاً في حفظ تخلص مياه الشرب. الاختبارات البيطولوجية لجودة مياه الشرب أظهرت وجود بكتيري E.coli &Thermo intolerant (E.coli &Thermo tolerant) في عينات المياه التي تم فحصها، الاختبارات الفيزيائية و الكيميائية لمياه الشرب أظهرت نتائج أقل من الحدود المسموح بها لكل من العناصر و الخواص التي تم اختيارها. يستخدم التلاميذ أكوام من الستيبل و البلاستيك لتناول وشرب المياه 96% من المدارس بها مراوح مخصصة و منفصلة لكل من المعلمين و التلاميذ وحسب النوع، نظيفة و سهلة الفتح و القفل و الاستخدام. 60% من المدارس يشتمل برامج نقل النفايات الصلبة و الوضوء الأخرى يتم بحرية داخل أو جوار المدرسة. جودة وسلامة مياه الشرب و استخداماتها، توفر وسائل الأصحاح و استخداماتها و المحافظة عليها و تعزيز الصحة و تدريب المعلمين في جميع مكونات المنهج الدراسي يقوم المعلمين بتدريبها من خلال العام الدراسي. بعض المعلمين تلقوا دورات تدريبية

عن تعزيز الصحة و سلامة البيئة المدرسية.

التوصيات: الاهتمام بتوفير خدمات مياه الشرب النقيه و رصد الجودة و السلامة دورياً، التوعي في توفير و تحسين خدمات الأصحاح بالمدارس، تفعيل برنامج وجمع و نقل النفايات الصلبة من المدارس و تقوية الشراكه في مجال دعم و توفير خدمات الأصحاح بالمدارس.

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Chapter 1
Introduction & Literature Review
1-Introduction

All schools and educational facilities should have adequate water, sanitation and hygiene facilities to ensure the health of their pupils/ students and staff. The sanitary conditions of schools in rural and urban areas in developing countries are often appalling, creating health hazards and other negative impacts, thus schools are not safe for pupils/ students. Although water and sanitation facilities are recognized as fundamental for hygienic behavior and pupils/ students well-being, in practice, the sanitary conditions in most schools are woefully inadequate. Water supply, sanitation and hand washing facilities are either non-existent, too few or inadequate due to poor maintenance of water systems and toilets or latrines. Lack of facilities is only part of the problem. (Burgers 2000.)

Access to adequate sanitation facilities is essential for children, as their right to health and survival depends on it. The dangers of the spread of diseases increase greatly when large numbers of children are brought together on a daily basis at school. It is therefore critical that hygiene practices and the necessary toilet facilities are made available at school. Due to the importance of water and sanitation to the survival, quality of life, health and development of children, one of the Millennium Development Goals is to halve, the proportion of people without access to basic sanitation by 2015. If a country’s water supply and sanitation is not sufficient or is of poor quality, diseases such as cholera and diarrhoea will be common. The causes of infant and child deaths can give a good indication of whether water supply and sanitation is adequate and sufficient. Lack of access to safe water will contribute to high numbers of babies and children dying of diarrhoea, it is a clear indication that many people are not able to access safe water and appropriate sanitation facilities.
2: Justification

The sanitary conditions in most schools are woefully inadequate. Water supply, sanitation and hand washing facilities are either non-existent, too few or inadequate due to poor maintenance of water systems and toilets or latrines. By including sanitation and hygiene in the Millennium Development Goals the global community has acknowledged the importance of promoting sanitation and hygiene as development interventions and has set a series of goals and targets to:

- Half, by 2015, the proportion of people without access to basic sanitation
- Improve sanitation in public institutions, especially schools
- Promote safe hygiene practices.

Every school plan shall be provided with toilet and hand washing facilities for all occupants. These facilities shall be located for convenient student access and kept clean and in good repair. School staff facilities shall be provided in separate rooms from student facilities.

Lack of facilities and poor hygiene affect both girls and boys, although poor sanitation conditions at schools have a stronger negative impact on girls. All girls should have access to safe, clean, separate and private sanitation facilities in their schools. If there are no latrines, hand-washing facilities at school or if they are in a poor state of repair, then many children would rather not attend than use the alternatives. In particular girls who are old enough to menstruate need to have adequate facilities at school and normally separate from those of boys.

At present, there are no qualified studies on the field of sanitation facilities/services and practices in schools in the rural and urban schools in the Sudan.
3: Objectives

1-3-1/ General Objective:

The general objective of this study is:

To assess the schools sanitation facilities and the impact on schools pupils /students health

1-3-2/ Specific Objectives: These are to

1. Identify and assess the drinking water quality risk point at schools.
2. Determine the availability, types/function and use of the sanitation /latrines at schools.
3. Assess the awareness and solid waste management practices at schools
4: Literature review

4-1: School Water and sanitation

"Sanitation" is understood to mean "the promotion of hygiene and prevention of disease by maintenance of sanitary conditions". (WHO Europe, 1999)

Sanitation refers to excreta and wastewater management as well as runoff water and solid and industrial waste. (Cheick, 2004)

Diseases primarily transmitted through the faecal-oral route include infectious diarrhoea, typhoid, cholera and infectious hepatitis. Faecal-oral diseases are associated with acute symptoms (with a probability of death) and in some cases with delayed sequel. Transmission may occur through a variety of mechanisms, including consumption of contaminated water and food as well as through person-person contact. These are deal with together here, in order to emphasize the importance of local disease patterns rather than applying generic models.

The available evidence from health studies suggests that interventions are likely to be locality-specific and determined by timing and the interaction between different factors. As all the interventions deliver some improvement, the relative impacts of each may have limited relevance for policy. (WHO 2003)

In many countries, there exists a high prevalence of water and sanitation related diseases, causing many people, children in particular, to fall ill or even die. Improved hygiene practices are essential if transmission routes of water and sanitation related diseases to be cut. Whereas appropriate hygiene education can bring about the intention to change hygiene behavior, for most hygiene behaviors appropriate water and sanitation facilities needed to allow people to transform intention to change into real change.

School sanitation and hygiene refers to the combination of hardware and software components that are necessary to produce a healthy school environment and to develop or support safe hygiene behaviors. The hardware components include drinking water, hand washing and sanitary facilities in and around the school compound. The software components are activities that
promote conditions at school and practices of school staff that help to prevent water and sanitation-related diseases and parasites such as worms (UNICEF and IRC 1998).

In combination, can the two conditions (soft ware and hard ware) for better health of schoolchildren be met

- Availability of good facilities
- Adoption of healthy practices

4-1-1: Criteria for Sanitation Facilities
- Sufficient water and sanitation facilities (toilets, hand washing facilities, water supplies) available in the school grounds.
- Facilities provided are kept clean, are durable and the maintenance is well organized.
- The water and sanitation facilities are child, gender and age friendly.
- Everyone uses them

4-1-2: The basic facilities assumed for a school are:
- Safe adequate drinking water supply all year
- Toilets with water supplied,
- Hand washing facilities with soap
- Maintenance program to ensure they continue working.
  (UNICEF and IRC 1998)

4-1-3: Water and Sanitation in MDGs
The Millennium Development Goals (MDGs) represent a renewed commitment to overcome persistent poverty and to address many of the most enduring failures of human development. The MDGs agreed by the international community in 2000 comprise 8 goals, 18 targets and 48 indicators. Water interconnected with all eight MDGs and basic sanitation were added to the list at the 2002 World Summit on Sustainable Development in Johannesburg. Halving ‘by 2015, the proportion of people without sustainable access to safe
drinking water and basic sanitation’ is one of the quantified and time-bound targets defined for the MDGs. (IRC 2004)

**Table: A**

**MDGs water and sanitation targets and indicators**

**Goal 7:** Ensure environmental sustainability

<table>
<thead>
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<th>Targets</th>
<th>Indicators</th>
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<td><strong>Target 10:</strong> Half, by 2015, the proportion of people without sustainable access to safe drinking water</td>
<td>30. Proportion of population with sustainable access to an improved water source, urban and rural</td>
</tr>
<tr>
<td>Target 11: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers</td>
<td>31. Proportion of urban population with access to improved sanitation.</td>
</tr>
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<td></td>
<td>32. Proportion of households with access to secure tenure (owned or rented)</td>
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</tbody>
</table>

(UN 2008)

Since 1990, 1.6 billion people have gained access to safe water. At this rate, the world is expected to meet the drinking water target, which would require that 89% of the population of developing regions use improved sources of drinking water by 2015. Still, nearly one billion people today lack safe sources of drinking water.

Improvements in sanitation have failed to keep pace with population growth. In 21 countries in sub-Saharan Africa, only 16 per cent of the poorest quintile of the population have access to improved sanitation, compared to 79 per cent of the population in the richest quintile.
Almost a quarter of the developing world’s population lives without any form of sanitation. (UN 2008)

In indicator 32 includes the proportion of households with access to water (within 200 meters) and having a connection to a sewer. Both household access and sewerage connection are proxies of secure tenure as otherwise such investments would not be made. (IRC 2004)

4-1-4: Economic Benefits of Water and Sanitation hygiene in Schools

1. Reduces the health burden from waterborne diseases.
2. Keeps girls in school.
3. Improves children’s learning capacities.
4. Influences families’ hygienic practices.
5. Bolsters the health of future generations.
6. Helps break the cycle of poverty.

(UNICEF 2003)

4-1-5: Gender in School Sanitation

Gender refers to the different roles, rights, and responsibilities of men and women and the relations between them. Gender does not simply refer to women or men, but to the way their qualities, behaviors, and identities are determined through the process of socialization.

Gender is generally associated with unequal power and access to choices and resources. The different positions of women and men are influenced by historical, religious, economic and cultural realities. These relations and responsibilities can and do change over time. (UNDP 2006)

Household chores, such as fetching water from long distances, keep many girls out of school. Providing water closer to homes increases girls’ free time and boosts their school attendance. Most other household chores—including cleaning latrines and disposing of garbage—also fall to women and girls. When family members become sick (often due to hygiene-related diseases), girls are more likely to be kept home to care for them.
All children need a sanitary and hygienic learning environment, but the lack of sanitation and hygiene facilities in schools has a stronger negative impact on girls than on boys. Girls need safe, clean, separate and private sanitation facilities in their schools.

Every school should be equipped with latrines, but again the point is underlined of the importance of separate facilities for boys and girls in safe and secure child-friendly environments.(UNICEF 2007).

Women acutely affected by the absence of sanitary latrines:

- Women have to wait until dark to defecate and urinate in the open they tend to drink less during the day, resulting in all kinds of health problems such as urinary tract infections (UTIs).
- Women sexually assaulted or attacked when they go into the open to defecate and urinate.
- Hygienic conditions are often poor at public defecation areas, leading to worms and other water-borne diseases.
- Girls, particularly after puberty, miss school due to lack of proper sanitary facilities. (UNDP 2006)

“Every primary school in the world should be equipped with separate sanitary facilities for boys and girls and have a source of clean and safe drinking water.”(UNICEF 2000)

For Sudan country sanitation coverage in the urban area 50% with improved sanitation, 36% un improved, and 14% open defecation. The rural sanitation coverage in Sudan 24% improved sanitation, 23% un improved and 53% open defecation (WHO, UNICEF 2008)

4 -2: WATER SUPPLY

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking water can result in tangible benefits to health. Every effort should made to achieve a drinking-water quality as safe as practicable. “All peoples, whatever
their stage of development and social and economic condition, have the right to have access to drinking-water in quantities and of a quality equal to their basic needs.” WHO 1997

School authorities have the responsibility for providing a safe and adequate water supply for school use. When municipal water supply is used, primary responsibility for its source and purity rests with the municipality and the public health department. Yet the school district is responsible for proper installation and maintenance of the water facilities in the school. In addition to being free from contamination, water should be potable and sufficiently abundant for normal school needs. (Anderson.. etal, 1976).

Water intended for human consumption should be both safe and wholesome. This has been defined as water that is:

1. Free from pathogenic agent.
2. Free from harmful chemical substances.
3. Pleasant to the taste, i.e. free from color and odour.
4. Usable for domestic purposes.

4-2-1: Source of Water Supply:

The first step in designing a water supply system is to select a suitable source or combination of sources. The source must be capable of supplying enough water for the community. (WHO, 1993). Water may abstract for use from any one of the numbers of option in its movement through the hydrological cycle. Water sources must conform to two criteria (Park 2005):

1. The quantity must be sufficient to meet the present and future requirements.
2. The quality of water must be acceptable.

The three main sources of water are:
1. Rain Water:
Rain is the source of all water. Apart of the rain water sinks into ground water, part of it evaporates back into the atmosphere, and some runoff to form streams and rivers which flow ultimately into the sea (water cycle).
Rain water is the purest water in the nature. There are few places in the world depend upon rain as a source of water supply. (Park 2005)

2. Surface water
It is the main water supply in many areas. Surface water is prone to contamination from human and animal sources. As such it is never safe for human consumption unless subjected to sanitary protection and purification before use. Surface water supplies possess a high probability of organic, bacterial and viral contamination.
Surface water sources are rivers, tanks, lakes, wades and man made reservoir and sea water. (K. Park 2005)

3-Ground water
Ground water sources are among the most commonly exploited for rural water supplies. The reason being that among the varies sources option, ground water is by far the most practical and safe in nature. (Park 2005)

In ground water supply investigations and design, the sanitarian and engineer are concerned with the following steps:

1. To locate a source with required quantity and quality as near as possible to the centre of consumption, in order to reduce transport costs.
2. To extract the water by means of a system which produce the quantity required, safeguards the quality.
3. To transport the water to the consumer in a way which requires the least amount of operational and maintenance skill and cost. (K. Park 2005)

The usual ground water sources are wells and springs.
4- Wells:
Wells are an important source of water supply in many countries. It divided to
Shallow wells and deep wells. According to the method of wells construction
are classified to dug wells and tube wells. (Park 2005)

4-2-2: Water Use and consumption:
Community water supply is a capital-intensive utility. Water for domestic
purposes is needed for drinking, food preparation and cooking, bathing,
ablution, washing cooking utilities, washing clothes, flushing, animals and
house cleaning.
Water use and consumption are frequently expressed in liters per capita
(Head). Schools water requirements are:

Table B: School water requirements’

<table>
<thead>
<tr>
<th>Category</th>
<th>Typical Water Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day schools</td>
<td>15-30 L/day/per pupil</td>
</tr>
<tr>
<td>Boarding schools</td>
<td>90-140 L/day/per pupil</td>
</tr>
</tbody>
</table>

(WHO1993)

4-2-3: Water quality – Criteria and standards:

4-2-3-1: Physical Parameters
Water physical characteristics can be divided in. Turbidity, Temperature,
Colour, taste and Odour, Solids and Conductivity.

1. Hydrogen Ion Concentration (PH)
The PH is a measure of the acid or alkaline of a solution and effect the water
quality (Abdelmajid & Rowe, 1995). The normal Ph of water is 7 as neutrality
.Below 7 being acid and above 7 being alkaline. Its an important parameter for
water.

2. Alkalinity
Alkalinity is a measure of the buffering of water. Alkalinity is caused primarily
by chemical compounds dissolved from the rocks and soil and is mainly due to
the presence of hydroxyl, carbonate and bi carbonate ions. These compounds
are mostly the carbonates of sodium, potassium, magnesium. (Abdelmajid & Rowe 1995).

3. Turbidity:
Turbidity is measure of the ability of water to scatter light and is caused by small particles in the water (Jackson etal, (1989)
Drinking water should be free from turbidity. Turbidity in drinking water is caused by particle matters that may be present as a consequence of in adequate treatment or from re suspension of sediment in the distribution system. It also be due to the presence of in organic matters in some ground water. Water with turbidity less than 5 Nephlometric Turbidity Unit (NTU) is accepted. (Park 2005)

4. Color : Drinking water should be free from colour which may be due to the presence of coloured organic matter, metals such as Iron and manganese, or highly coloured industrial wastes. The guide lines value is up to 15 true colour units (TCU) is accepted. (Park 2005)

5. Taste and Odour
It is indicative of some form of pollution or mal function during the water treatment or distribution. Taste and Odours may be an indicator of the appearance of harmful substances. (Park 2005)

4-2-3-2: Chemical aspects of water
Most chemicals arising in drinking-water are of health concern only after extended exposure of years, rather than months. The principal exception is nitrate. Typically, changes in water quality occur progressively, except for those substances that are discharged or leach intermittently to flowing surface waters or groundwater supplies from, for example, contaminated landfill sites. (WHO 2006)

1. Chloride
Chloride in drinking-water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt and saline intrusion.
The main source of human exposure to chloride is the addition of salt to food, and the intake from this source is usually greatly in excess of that from drinking-water. Excessive chloride concentrations increase rates of corrosion of metals in the distribution system, depending on the alkalinity of the water. This can lead to increased concentrations of metals in the supply.

No health-based guideline value is proposed for chloride in drinking-water. However, chloride concentrations in excess of about 250 mg/litre can give rise to detectable taste in water.

2. Hardness

Hardness in water is caused by dissolved calcium and, to a lesser extent, magnesium. It is usually expressed as the equivalent quantity of calcium carbonate.

Depending on pH and alkalinity, hardness above about 200 mg/litre can result in scale deposition, particularly on heating. Soft waters with a hardness of less than about 100 mg/litre have a low buffering capacity and may be more corrosive to water pipes.

A number of ecological and analytical epidemiological studies have shown a statistically significant inverse relationship between hardness of drinking water and cardiovascular diseases. There is some indication that very soft waters may have an adverse effect on mineral balance, but detailed studies were not available for evaluation.

No health-based guideline value is proposed for hardness. However, the degree of hardness in water may affect its acceptability to the consumer in terms of taste and scale deposition.

3. Fluoride

Fluoride accounts for about 0.3 g/kg of the Earth’s crust and exists in the form of fluorides in a number of minerals. The most important source of fluoride in drinking water is naturally occurring. Inorganic fluoride-containing minerals are used widely in industry for a wide range of purposes, including aluminum
production. Fluorides released to the environment from the phosphate-containing rock used to produce phosphate fertilizers; these phosphate deposits contain about 4% fluorine.

Fluorosilicic acid, sodium hexafluorosilicate and sodium fluoride is used in municipal water fluoridation schemes. Daily exposure to fluoride depends mainly on the geographical area. In most circumstances, food seems to be the primary source of fluoride intake, with lesser contributions from drinking-water and from toothpaste. In areas with relatively high concentrations, particularly in groundwater, drinking-water becomes increasingly important as a source of fluoride. Intakes in areas where high fluoride coal is used indoors may also be significant. (WHO 2006)

At level of fluoride in drinking water greater than 5 mg/L, the consumer may suffer from flourisis which is hardening of the bones and mottling of the teeth. (Jackson, Morris, Smith and Graford 1989)

4. Iron

Iron is one of the most abundant metals in the Earth’s crust. It is found in natural fresh waters at levels ranging from 0.5 to 50 mg/litre. Iron may also be present in drinking-water as a result of the use of iron coagulants or the corrosion of steel and cast iron pipes during water distribution.

Iron is an essential element in human nutrition. Estimates of the minimum daily requirement for iron depend on age, sex, physiological status and iron bioavailability and range from about 10 to 50mg/day. (WHO 2006)

4-2-3-3: Water supply, hygiene and disease

Infectious diseases caused by pathogenic bacteria, viruses and parasites (e.g., protozoa and helminthes) are the most common and widespread health risk associated with drinking-water. The public health burden is determined by the severity of the illness(es) associated with pathogens, their infectivity and the population exposed.
Breakdown in water supply safety may lead to large-scale contamination and potentially to detectable disease outbreaks. Other breakdowns and low-level, potentially repeated contamination may lead to significant sporadic disease, but is unlikely to be associated with the drinking-water source by public health surveillance (WHO 2006).

Classifying diseases by causative agent such as microbe type for infectious disease has a value in terms of understanding etiology of infection. However, a more effective way to inform decision-making is to categories pathogens /diseases in relation to the broad mode of transmission. There are four principal categories (WHO 2003)

1. **water-borne** - caused through consumption of contaminated water (for instance diarrhoeal diseases, infectious hepatitis, typhoid, guinea worm);
2. **water-washed** - caused through the use of inadequate volumes for personal hygiene (for instance diarrhoeal disease, infectious hepatitis, typhoid, trachoma, skin and eye infections);
3. **water-based** - where an intermediate aquatic host is required (for instance guinea worm, schistosomiasis);
4. **water-related vector** - spread through insect vectors associated with water (for instance malaria, dengue fever).

**4-2-3- 4-: Bacteriological Indicator for water microbial quality**

*Escherichia coli (E. coli):*

Is a member of the family Entero bacteriaceae, and characterized by possession of the enzymes b-galactosidase and b-glucuronidase. It grows at 44–45°C on complex media, ferments lactose and mannitol with the production of acid and gas, and produces indole from tryptophan. However, some strains can grow at 37 °C but not at 44–45°C, and some not produce gas. E. coli does not produce oxidase or hydrolyse urea. Complete identification of the organism is too complicated for routine use, but a number of tests have been developed for rapid and reliable identification. Some of these methods have been standardized at
international and national levels and accepted for routine use; others are still being developed or evaluated.

*Escherichia coli* (E.coli) is abundant in human and animal faeces; in fresh faeces it may attain concentrations of $10^9$/gram. It is found in sewage, treated effluents, and all natural waters and soils subject to recent faecal contamination, whether from humans, wild animals, or agricultural activity. Recently, it has been suggested that E. coli may be present or even multiply in tropical waters not subject to human faecal pollution. However, even in the remotest regions, faecal contamination by wild animals, including birds, can never be excluded. Because animals can transmit pathogens that are infective in humans, the presence of E. coli or thermo tolerant coli form bacteria must not be ignored, because the presumption remains that the water has been faecally contaminated and that treatment has been ineffective. (WHO 1997)

**Thermo tolerant coli form bacteria**

Thermo tolerant coli form bacteria are the coli form organisms that are able to ferment lactose at 44–45°C; the group includes the genus *Escherichia* and some species of *Klebsiella*, *Enterobacter*, and *Citrobacter*. Thermotolerant coli forms other than E. coli may also originate from organically enriched water such as industrial effluents or from decaying plant materials and soils. Re-growth of thermo tolerant coli form organisms in the distribution system is unlikely unless sufficient bacterial nutrients are present, unsuitable materials are in contact with the treated water, the water temperature is above 13 °C, and there is no free residual chlorine.

In most circumstances, concentrations of thermo tolerant coli forms are directly related to that of E. coli. Their use in assessing water quality is therefore considered acceptable for routine purposes, but the limitations with regard to specificity should always be borne in mind when the data are interpreted. If high counts of thermo tolerant coli forms are found in the absence of detectable
sanitary hazards, additional confirmatory tests specific for E. coli should be carried out.

National reference laboratories developing national standard methods are advised to examine the specificity of the thermo tolerant coli form test for E. coli under local conditions.

Because thermo tolerant coli form organisms are readily detected, they have an important secondary role as indicators of the efficiency of water-treatment processes in removing faecal bacteria. They may therefore be used in assessing the degree of treatment necessary for waters of different quality and for defining performance targets for removal of bacteria. (WHO 1997)

**Coli form organisms** *(total coli forms)*: Coli form organisms have long been recognized as a suitable microbial indicator of drinking-water quality, largely because they are easy to detect and enumerate in water. The term “coli form organisms” refers to Gram-negative, rod-shaped bacteria capable of growth in the presence of bile salts or other surface-active agents with similar growth-inhibiting properties and able to ferment lactose at 35–37°C with the production of acid, gas, and aldehyde within 24–48 hours. They are also oxidase-negative and non-spore-forming and display β-alactosidase activity.

The existence both of non-faecal bacteria that fit the definitions of coli form bacteria and of lactose-negative coli form bacteria limits the applicability of this group as an indicator of faecal pollution. Coli form bacteria should not be detectable in treated water supplies and, if found, suggest inadequate treatment, post treatment contamination, or excessive nutrients. The coli form test can therefore be used as an indicator both of treatment efficiency and of the integrity of the distribution system. Although coli form organisms may not always be directly related to the presence of faecal contamination or pathogens in drinking-water, the coli form test is still useful for monitoring the microbial quality of treated Piped water supplies. If there is any doubt, especially when
coli form organisms are found in the absence of thermo tolerant coli forms and E. coli, identification to the species level or analyses for other indicator organisms may be undertaken to investigate the nature of the contamination. Sanitary inspections will also be needed. (WHO 1997)

**Faecal streptococci** : Faecal streptococci are those streptococci generally present in the faeces of humans and animals. All possess the Lance field group D antigen. Taxonomically, they belong to the genera Enterococcus and Streptococcus.

In the genus Streptococcus, only S. bovis and S. equinus possess the group Antigen and therefore belong to the faecal streptococcus group. They derive mainly from animal faeces. Faecal streptococci rarely multiply in polluted water, and they are more persistent than E. coli and coliform bacteria. Their primary value in water-quality examination is therefore as additional indicators of treatment efficiency. Moreover, streptococci are highly resistant to drying and may be valuable for routine control after new mains are laid or distribution systems are repaired, or for detecting pollution of ground waters or surface waters by surface run-off. (WHO 1997)

**Table .C**

**WHO Guideline values for verification of microbial quality**

<table>
<thead>
<tr>
<th>Organisms</th>
<th>Guideline value</th>
</tr>
</thead>
<tbody>
<tr>
<td>• All water directly intended for drinking</td>
<td>Must not be detectable in any 100-ml sample</td>
</tr>
<tr>
<td>E. coli or thermo tolerant coli form bacteria,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Must not be detectable in any 100-ml sample</td>
</tr>
<tr>
<td>• Treated water entering the distribution system</td>
<td></td>
</tr>
<tr>
<td>E. coli or thermo tolerant coli form bacteria</td>
<td>Must not be detectable in any 100-ml sample</td>
</tr>
<tr>
<td>• Treated water in the distribution system</td>
<td></td>
</tr>
<tr>
<td>E. coli or thermo tolerant coli form bacteria,</td>
<td>Must not be detectable in any 100-ml sample</td>
</tr>
<tr>
<td>(WHO 2006)</td>
<td></td>
</tr>
</tbody>
</table>
4-2-2-Water treatment:
The concept of multiple barriers for water treatment is the cornerstone of safe drinking-water production. The barriers are selected so that the removal capabilities of different steps in the treatment process are duplicated. This approach provides sufficient backup to allow operations typically include periods of ineffectiveness. Having multiple barriers continuous operation in the face of normal fluctuations in performance, which means that a failure of one barrier can be compensated for by effective operation of the remaining barriers, minimizing the likelihood that contaminants will pass through the treatment system and harm consumers. Traditionally, the barriers have included:

1. protection of source water (water used for drinking-water should originate from the highest quality source possible);
2. coagulation, flocculation and sedimentation;
3. filtration;
4. disinfection;
5. Protection of the distribution system.

(WHO 2004)

Disinfection:
Disinfection is used in water treatment to reduce pathogens content (disease-producing microorganisms) to an acceptable level. The disinfectants must persist within disinfected water in a sufficient concentration to provide reasonable residual protection against its possible recontamination before use. (Mackenzie 1998).

Disinfection processes:
1. Pre-treatment oxidation: in which oxidants are added to water early in the treatment process.
2. Primary disinfection — a common component of primary treatment of drinking-water, and important because granular filter media do not remove all microbial pathogens from water
3. **Secondary disinfection** — used to maintain the water quality achieved at the treatment plant throughout the distribution system up to the tap. (WHO 2004)

4-2-3: Storage Vessels for Water

In developing countries, many of the traditional types of water collection and storage methods employing vessels of various compositions and sizes are still widely used today. These include traditional pots or urns fashioned from natural materials (e.g., gourds or wood) or fabricated from clay, copper, brass and other impervious materials, and flexible bags or other vessels made of animal hides, other animal parts or fabrics treated to seal and prevent leakage. Today, other metals, including aluminum, steel and iron, as well as other materials, primarily plastics, have come into widespread use for water collection and storage in the form of buckets, jerry cans, picnic coolers and other vessel types and shapes. Cisterns and other basins are also still widely used for water collection and bulk storage near or adjacent to dwellings, as they have been since ancient times. Some of the key factors influencing the impact of storage vessels and conditions on household water quality are:

1. **Portability** and ease of use, based on capacity, size, shape, weight, presence of handles.
2. **Durability**, weight and other properties related to resistance and longevity.
3. **Presence** of a coverable (preferably screw-cap) opening for filling and cleaning access but small enough to reduce the potential for introducing contaminants by contaminated hands, dipping utensils and other vehicles (e.g., airborne dust), vectors, or other sources.
4. **Ability** to withdraw water in a sanitary manner, such as via a tap, spigot, spout or other narrow orifice.
5. **Presence** and accessibility of documentation describing how to properly use the container for water treatment and sanitary storage.

The most desirable water storage vessels options are:
Between 10-25 liters capacity, rectangular or cylindrical with one or more handles and flat bottoms for portability and ease of storage.

Made of lightweight, oxidation-resistant plastic, such as high-density polyethylene or polypropylene, for durability and shock resistance.

Fitted with a 6-9 cm screw-cap opening to facilitate cleaning, but small enough to discourage or prevent the introduction of hands or dipping utensils.

Fitted with a durable, protected and easily closed spigot or spout for dispensing water.

Provided with pictorial and/or written instructions for use affixed permanently to the container, as well as an affixed certificate of approval or authenticity. The cost of water storage vessels is also an important consideration, as they must be affordable or be subsidized. Locally available buckets, pots, urns, jerry cans, barrels, used beverage containers and flexible bags and flagons are usually low in cost and readily available. However, only some of these, in particular jerry cans, some plastic beverage containers, some urns and some flexible vessels, have properties and characteristics that are preferred or desirable as readily transported water storage vessels. (WHO, 2002).

4-2-3-1: Household Water Storage, Microbial Quality and Infectious Disease Risks

Key factors in the provision of safe household water include the conditions and practices of water collection and storage and the choice of water collection and storage containers or vessels. Numerous studies have documented inadequate storage conditions and vulnerable water storage containers as factors contributing to increased microbial contamination and decreased microbial quality compared to either source waters or water stored in improved vessels. Some studies also have documented increased risks of waterborne infectious diseases from inadequately stored water compared to water stored in an improved vessel, treated in the home to improve microbial quality, or consumed
from a quality source without storage. Higher levels of microbial contamination and decreased microbial quality are associated with storage vessels having wide openings (e.g., buckets and pots), vulnerability to introduction of hands, cups and dippers that can carry fecal contamination, and lack of a narrow opening for dispensing water. Some studies have noted the vulnerability of storage vessels with these undesirable characteristics to fecal and other contamination without having reported microbiological data on water quality or increased levels of diarrheal disease. Other factors contributing to greater risks of microbial contamination of stored water are higher temperatures, increased storage times, higher levels of airborne particulates (dust storms), inadequate hand washing and the use of stored water to prepare weanling and other foods that also become microbiologically contaminated and contribute to increased infectious disease (WHO2002)

4-3: Human excreta and sanitation

The various methods of human wastes disposal will be described focusing on the most common and acceptable types of latrines for use in the area. (George N .1992). They include:

- pour-flush toilet/latrine to:
- Piped sewer system
- Septic tank
- Pit latrine
- Ventilated improved pit latrine (VIP)
- Composting toilet.
- Sewerages.

(UNICEF 2008)

4-3-1: Needs of toilets

Health is not always the main reason why people want to have clean toilets, better water supplies, or improved hygiene. Other needs may include:
Privacy: A toilet can be as simple as a deep hole in the ground. But the need for privacy makes it important for a toilet to have a good shelter. Making a door or enclosed entrance to a toilet, or building it away from where people usually walk, will make it nicer to use. The best shelters are simple and are built from local materials.

Safety: If a toilet is badly built it can be dangerous to use. And if it is far from the home, women may be in danger of sexual violence when they take care of their sanitation needs. For a toilet to be safe it must be well-built and in a safe place.

Comfort: People will more likely use a toilet with a comfortable place to sit or squat, and a shelter large enough to stand up and move around in. They will also be more likely to use a toilet that is close to the house and that gives protection from wind, rain, or snow.

Cleanliness: If a toilet is dirty and smelly, no one will want to use it — and it may spread disease. Sharing the task of cleaning or paying for cleaning with money or other benefits will help to ensure that toilets are kept clean.

Respect: A well-kept toilet brings status and respect to its owner. Often this is a very important reason for people to spend the money and effort to build one. (Hesperian Foundation and UNDP 2005)

4-3-2: On-site sanitation

On-site sanitation is the whole of actions related to the treatment and disposal of domestic waste water that cannot be carried away by an off-site sanitation system because of low density of population (Cheick 2004)

The autonomous part of on-site sanitation refers to the techniques used (purification of water), its design, as well as its financing, implementation and maintenance.

Because the autonomous part of on-site sanitation is defined as such it is often regarded as the opposite of off-site sanitation, although the boundary between the two systems is not always as clear and well-identified.
4-3-3-3 School latrines

A school latrine to be selected for implementation should be checked against the Following basic requirements.

- It should be simple in design, construction, operation and maintenance. Local semi-skilled persons should be able to construct it.
- It should be a good exemplary for hygiene promotion activities within and outside of the school.
- It should be low-cost and should allow, as much as possible, the use of locally available materials.
- It should be hygienic (free from bad smell), inaccessible to insects, flies and animals) and should not contaminate ground water.
- It should ensure safe disposal of excreta.
- It should be culturally acceptable to the users and allow regular service with out interruption.
- Schools are major entry points to bring behavioral changes among youth groups.
- Students could influence positively the society. Therefore, establishing school hygiene clubs, for this purpose, is a very important tool to communicate hygiene messages in addition to construction of school latrines.
- Advocacy at different levels (at Mahalia, State and National levels) should be incorporated and be in place for schools to include hygiene promotion in their curriculum.
- It should not deprive minimum safety and privacy to the school community, and it should have the following basic components:
- A platform in which the user can defecate easily and safely. The platform may have a squatting pan or a simple drop hole or a straight pipe depending on the type of latrine selected. The number of drop holes or
pans depends on the number of students. 50 students are expected to be served by one drop hole in boys’ school and 30 students in girls’ school. Vent pipes with fly screens should be provided outside of the superstructure. Where it is anticipated that emptying of the pit is possible, a manhole should be provided on the

- The superstructure could be constructed from locally available affordable materials like redbrick, hollow block, mud brick, stone etc. Stakeholders should decide on the type of material to be used. The use of locally available material should not bring any significant negative impact to the environment. (UNICEF/WES 2008)

The types of latrines that have been considered for comparison include Pour-flush latrines (water-based latrines), ventilated improved pit latrines, improved traditional pit latrines, aqua privies and composting (ecosan) latrines. (UNICEF 2008).

When selecting which latrine is appropriate for particular situation, the following points have to be taken into account:

- The availability of the resources to be used.
- Affordability and social acceptability of the Latrine.
- The availability of adequate land and space for future expansion.
- The sanitary features and their safety to the users.
- The problem of repair and maintenance of each latrine.

1-Ventilated Pit Latrines (VIP latrine)

There are many types of VIP latrines:

1. The Single Pit Latrine.

   Single VIP latrines are suitable for use in rural areas where the soil is deep and permeable and the pit can be made as large and deep as necessary.

2. The alternating double-pit latrine
This kind of latrine is designed to have a permanent structure with two pits that are used alternatively. It's more appropriate in urban areas.

3. The Multiple – pit Latrine.

This type of VIP latrines is designed for communal use (e. g .Schools). Each compartment is designed for 25 users .after designing the multiple – pit latrine, the pit is dug and the divided in to the required number of compartments .Deviation is done after adequate depth has been dug and the slab put in position .The partition between the compartments should be air tight for effective ventilation and should go all the way to the bottom of the pit.

**Operation of a vent pipe:**

A vent pipe work on the principle of stack effect .Air movement across the top of the vent pipe cause suction in the pipe witch pulls the air up the vent pipe. Air moving up also pulls air out of the pipe .air leaving the pit pulls air down the squat hole in to the pit its important that the vent pipe or chimney is sealed around its entire surface. It’s also sealed completely at its base where it joints the slab. The minimum height for the vent pipe above the highest part of the roof is 450 to 600 mm.

**Maintenance:**

VIP latrines are very easy to maintain and clean .cleaning should be done regularly .the repairs of any part of the latrine are easy because it can be done by the local people using locally available materials.

A disinfectant or bleach should be used for cleaning the floor.

There are two parts of the latrine need periodic inspection:

1. The fly screen at the top of the vent pipe should be kept clear of materials witch might block it. The screen should be replaced if it is tom.

**2- Pour Flush Latrines**

Pour Flush Latrines have a water seal which makes them hygienic. The water seal trap is built in to the concrete floor .The top level of the pan should be level
with the floor. The water seal trap is placed directly over a pit or the trap can be connected to a drain which discharges into a soakage pit.

**Operation:**

Two important reactions take place in the pit:

1. One or two liters of water are used to flush the toilet after defecation. The liquid portion of the excreta is absorbed into the surrounding soil.
2. The solid excreta are broken down biologically by an aerobic bacteria. This digestion by bacteria reduce the accumulation of solids in the pit. Thus the pit can be used for quite a long time.

The water-seal trap is important for the hygienic function of a pour-flush latrines. The trap prevents smells in the pit from escaping through the toilet. It also prevent insects from leaving or interring the pit. (George, 1992)

**Maintenance:**

The toilet bowl and the floor need regular cleaning using disinfectant. The superstructure should also be kept in a good state of repair. The users should be advised not to use bulky materials because they will block the drains. If the drain is blocked, open the top cork outside the compartment by turning it anti-clockwise. When it is opened remove the materials which are blocking it.

**3- The septic tank**

A Septic tank is chamber which is either cylindrical or rectangular. It is normally constructed in the ground. It receives sewages from toilets and other waste water from Kitchens and bathrooms. The sewage enters the septic tanks from the inlet which is baffled. The heavy particles are directed to the bottom where the settle. The heavy particles (sludge) at the bottom are digested anaerobically. Lighter materials, including fats and grease rise to the top to form scum. The scum gradually thickens and the sludge accumulates until it becomes necessary to remove the sludge.

The effluent leaves the tank through an outlet which is also baffled. The outlet, which is 50mm lower than the inlet, acts as an over flow. The outlet is also
used in determining the level of sewage in the Septic Tank. The depth of sewage in septic tank varies from 1.05 m to 1.8 m. The effluent leaves the tank and enters a soakage pit.

The treatment of sewage in septic tank starts with sedimentation and fermentation and then flowed by decomposition of both the sludge and the scum. Colloidal organic matter in suspension is also flocculated and digested. The detention period of treating sewage by the se of septic tank is between 24 to 48 hours. The tanks should be dosed with activated sewage to increase biological digestion. The tank is then filled with water which is free from chlorine or any disinfectant. A septic tank is commonly used in treating sewage from health centers, isolated houses with piped water and schools. A septic tank is about 1.5 m deep. It is divided in to two compartments. The first compartment is two to third of the whole length and second part is one-third .

The tanks s constructed of stones bricks or blocks .It consist of a water tight chamber which are also water tight and air tight . (George , 1992)

**Aqua Privies (AP)**

Aqua privies are more appropriate for rural and semi-urban areas where water is available and the service of emptying the pit is not a problem. They need a provision for soaking in to the ground through a soak away for the liquid effluent as it is dangerous as raw sewage from health point of view. Regular cleaning of the toilet with detergent in normal amounts might not be harmful.

The use of large amounts of detergent or chemicals may disturb the biochemical process in a tank.

The amount of liquid in the tank should be kept high enough to keep the bottom of the drop pipe at least 75mm below the liquid level. A bucket of water should be poured down the drop pipe daily in order to clear scum from the bottom of the drop pipe and to maintain the water seal.
Routine inspection is necessary to check whether desludging is needed or not. The tank should be emptied when solids occupy between one-half and two-thirds of the total depth between the liquid level and the bottom of the tank.

4- Sewerage:
Discharge from WCs and other liquid wastes flow along a system of sewers to treatment works or directly into the sea or a river.
Usual (small-bore sewerage), sewers built nearer to the surface than usual, and sewers with flatter gradient than usual have been tried. Many of these systems require a chamber at each house to retain solids, which have to be removed and disposed of from time to time. Some of these systems have been found to be suitable for providing sanitation simultaneously for a large number of high-density dwellings. (WHO, 1992)

Urinal:
As quite a lot of students may need the latrine for urination only, urinals should be provided in addition to the latrines. A horizontal space of 0.5m is enough for one student.

The height, shape or type of urinal, however, should be decided by the school communities taking into consideration the local culture and convenience of the urinals.
Urinal for boys could be rectangular in shape and has a size of 0.5m by 0.25m by 4m as indicated in this guideline. It can be used by 8 students at any one time. Unlike for boys, urinals for a girl should have a minimum area of 0.5m by 0.6m and height of 1.2m. (UNICEF, 2008)

5- Hand washing facility:
Each latrine should be provided with hand washing facility. The type and appropriateness of such facilities should conform to the availability of hand washing materials like soap and detergent and should be selected and agreed by the school communities. Where hand washing materials other than soap and detergent are being used, the hand washing facilities should be compatible for
such materials. The waste water from hand washing facilities should be properly drained and directed to soak away pit. Water logging around such facilities should not be observed in anyway. The minimum standard includes:

- One squatting slab should be provided for 50 boys or 30 girls within 50m distance from the class rooms. During emergencies (as per Sphere Minimum Standard)
- A minimum of one squatting hole for 50 students (boys or girls) should be provided.
- A minimum space of width of 0.80 to 0.90m and length of 1.0m should be provided for every squatting space.
- And rectangular pits in hard and stable formation.

In addition one or two squatting slabs for teachers and other employees of the school are recommended. In co-education schools, latrines for boys and girls shall be separated with a minimum distance of 30m.

Although a minimum distance of 15m is possible in other countries, it is recommended in Sudan that pits have to be located at a minimum distance of 30 to 50 meters away from drinking water sources (tube wells and hand dug wells) depending on soil condition. The necessary distance depends on hydro-geological conditions such as texture of the soil and groundwater depth and flow. When groundwater levels are high or when the soil is too hard to dig, the pit may have to be raised above ground level.

All types of school latrines must have hand washing facilities and urinals. Hand washing facilities at two locations should be in place in co-education schools. Appropriate urinals that could be culturally acceptable must be designed in consultation. (UNICEF, 2008).

4.4: Solid waste management practice

Solid waste are defined as (the unwanted remains, residues, discarded materials or by products which are no longer required by the initial user) George 1992. These materials are the by-products of human activities. Such activities include
the process of preparation, manufacture, packing, repacking, unpacking, and construction and renovation of intriguers. (George 1992).

4-4-1: Solid waste can be classified in different ways. The more usual classifications take into account the waste’s potential risk for environmental contamination or its nature and origin.

1. **Potential environmental contamination risks**

   Solid waste can be classified as:

   **CLASS I: HAZARDOUS SOLID WASTE**

   Solid waste that is intrinsically inflammable, corrosive, reactive, toxic or pathogenic and therefore represents a risk to public health in the form of increased mortality or morbidity, or produces adverse environmental impacts when inappropriately handled or disposed of.

   **CLASS II: NON-INERT SOLID WASTE**

   Combustible, biodegradable or soluble waste that can represent health or environmental risks but does not fall within Class I, hazardous waste, or Class III, inert waste.

   **CLASS III: INERT SOLID WASTE**

   The waste with intrinsic characteristics that do not represent a risk to health or the environment and that when sampled in a representative way in accordance with the relevant norms, and subjected to static or dynamic contact with distillate or deionizer water at room temperature (dissolution tests), does not have any of its dissolved components in concentrations higher than those in drinking water patterns, except in regard to aspect, color, turbidity and taste.

2. **Nature and origin**

   Origin is the principal element in categorizing solid waste. According to this criterion, solid waste can be grouped in five categories:

   - Residential or domestic waste
   - Commercial waste
• Street waste

• Special domestic waste:
  a. rubble
  b. batteries
  c. fluorescent tubes
  d. tyres

• Special origin waste:
  o industrial waste
  o radioactive waste
  o port, airport, railway station and bus terminal waste
  o agricultural waste
  o medical waste

SPECIAL ORIGIN WASTE
Waste that due to its particular characteristics requires special handling, preparation, storage, transport and final disposal. The main types of special origin waste are:

1. Industrial waste
Waste generated by industrial activity. Its composition varies greatly according to the type of product that is being made. Consequently it is necessary to examine each case individually in order to categorize it as Class I (hazardous), Class II (non-inert) or Class III (inert).

2. Radioactive waste is the waste that emits radiation in excess of limits stipulated by environmental law. Due to its specific nature and dangerous characteristics its handling, storage and final disposal are the responsibility of national public bodies and are subject to very rigorous controls. In Brazil, for example, handling, storage and final disposal of radioactive waste is undertaken by the National Nuclear Energy Commission.
3. Agricultural waste
This category mostly comprises the remains of containers and packaging impregnated with dangerous pesticides and chemical fertilizers used in agriculture. The handling of this type of waste should therefore follow the same practices and use of the same containers and process as those used for the handling of Class I industrial waste. Due to a lack of controls and low fines for inappropriate handling of this type of waste, it is often mixed with common waste and disposed of in municipal dumps or even worse, thrown into bodies of water or is burnt in remote rural establishments thus generating toxic gases.

4. Medical waste
This category consists of all the waste generated by healthcare institutions.

Table D: CHARACTERISTICS and TYPES OF WASTES

<table>
<thead>
<tr>
<th>Types of Wastes</th>
<th>Waste components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Old newspapers</td>
<td>Newspapers, comics, magazines</td>
</tr>
<tr>
<td>2. Paper &amp; cardboard</td>
<td>Wrapping paper, paper bags, paper towels,</td>
</tr>
<tr>
<td></td>
<td>Writing paper, cigarette packages, books</td>
</tr>
<tr>
<td></td>
<td>Corrugated paper &amp; boxes, etc.</td>
</tr>
<tr>
<td>3. Food wastes</td>
<td>Vegetable &amp; fruit discards and peelings,</td>
</tr>
<tr>
<td></td>
<td>Eggshells, spoiled food and bread,</td>
</tr>
<tr>
<td></td>
<td>Meat and fish bones, etc.</td>
</tr>
<tr>
<td>4. Plastic</td>
<td>Plastic bags, plastic containers, toys,</td>
</tr>
<tr>
<td></td>
<td>Styrofoam, etc.</td>
</tr>
<tr>
<td>5. Textiles</td>
<td>Clothing, rags, carpets, hats, other fabric</td>
</tr>
<tr>
<td>6. Rubber &amp; leather</td>
<td>Rubber tires, leather shoes, handbags, etc.</td>
</tr>
<tr>
<td>7. Petroleum products</td>
<td>Oil, grease, etc.</td>
</tr>
<tr>
<td>9. Wood</td>
<td>Lumber, plywood, boxes, furniture, toys,</td>
</tr>
<tr>
<td></td>
<td>Tree branches, etc.</td>
</tr>
<tr>
<td>Types of Wastes</td>
<td>Waste components</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>10. Aluminum cans</td>
<td>Cans and other aluminum containers</td>
</tr>
<tr>
<td>11. Metals</td>
<td>Wire, auto parts, iron, steel, etc.</td>
</tr>
<tr>
<td>12. Glass</td>
<td>Bottles, jars, broken glass, etc.</td>
</tr>
<tr>
<td>13. Inert Material</td>
<td>Rocks, stones, tiles, ceramics, bricks, Sand, dirt, ashes, cinder, etc.</td>
</tr>
<tr>
<td>14. Hazardous wastes</td>
<td>Batteries, chemicals, pesticides, etc</td>
</tr>
</tbody>
</table>

( Ma. Eugenia C. Bennagen, Georgina Nepomuceno and Ramil Covar 2002)

4-4-2: **Solid waste preparation and storage**

Pre-collection solid waste preparation and storage should be done in an appropriately sanitary way taking into account the type and quantity of waste. The quality of solid waste collection and transportation operations depends on an appropriate preparation and storage of waste and its presence in the place, on the day and at the time established by the urban cleaning body responsible for collection.

Appropriate preparation and storage is important for:

- avoiding accidents;
- avoiding vector proliferation;
- minimizing visual and odors impacts;
- reducing waste heterogeneity (in the case of selective collection);
- Facilitating collection.

The choice of container type should be based on:

- Refuse characteristics;
- Quantity of refuse generated;
- Frequency of collection;
- type of building;
- Price of container.
Receptacles for domestic waste pre-collection storage should have the following characteristics:

- A maximum loaded weight of 30 kg if the collection is manual.
- Devices that facilitate its movement between its place in the building and the place of collection;
- closable in order to avoid waste spillage or exposure;
- Safe in that injury is not caused to users or collectors by sharp edged or pointed Waste, including when separately packaged;
- Economical and affordable for the general public;
- Not producing excessive noise when handled;
- Easy to empty without leaving waste at the bottom.

The most appropriate containers for pre-collection domestic waste storage are plastic bags, wheelie bins and metal containers.

**Plastic bags:** Waste can be stored in non-returnable plastic bags to be collected by collection vehicles. Such plastic bags should have the following characteristics:

- Resistance so that they do not break when handled;
- A capacity of 20, 30, 50 or 100 litres;
- A tape to close the top;
- A color standardized by the relevant body.

**Plastic wheelie bins:** These are containers made of high density polyethylene (HDPE) with a capacity of 120, 240 or 360 litres (two wheeled bins) and 760 or 1,100 litres (four wheeled containers), comprising a body, a lid and wheels. They are made of partly recycled material plus additives to protect them from the action of ultraviolet rays.

**Metal containers:** These receptacles, with a capacity that ranges between 750 and 1,500 liters, generally have four small wheels and can be emptied by means of tipping devices installed in compaction trucks.
**Waste collection and transport**
Collection is the removal of waste stored by the generator for dispatch by appropriate transport to a transfer station, treatment unit or final disposal site.
The collection and transportation of domestic waste generated in households and small-sized public, commercial or service establishments is generally undertaken by the municipal body responsible for urban cleaning. Municipalities may provide these services through their own resources, concessions to companies, outsourcing to companies, or mixed systems such as rented vehicles and municipal labour. (Ministry for the environment, Brazil and others 2008)

**Common domestic waste** collection can be defined as the collection of refuse produced in residential, public and commercial buildings, provided that the latter do not represent large generators. (Ministry for the environment Brazil 2008).

**Collection regularity:**
Domestic waste collection services to each building should be regular, always on the same days of the week and at the same times. When services are regular, citizens will become accustomed to taking waste containers or bags out to the pavement in front of their building a short time before the collection vehicle passes.
Regular collection is therefore one of the principal requirements for a good quality service. (Ministry for the environment Brazil 2008).
Chapter {2}

Materials and Methods
Materials and methods

Study area

Location:-
Elhaj Yousif administrative unit is one of Sharg Elneel locality, bordered by Eldroushab unit from the north, Omar Elmoukhtar unit from the west, Eljiraifat and Umdoum from the south, and Wadi souba administrative unit from the east.

Climate:-
Is Khartoum state climate where it is characterized by being hot and dry in summer, and cold in winter, rains average fall (160 mm) approximately?

Social and Economic status:-
Social and economic situation in the area linked with each other, and the levels are different according to the family income, where we find most residents enjoy with urban life, and some of them have middle incomes, and others working as employees.

Health situation:
There are three main public and environmental health services that implemented in the locality.

1- Preventive medicine and Environmental health:
This services carried out by environmental health staff (public Health officers, sanitary overseas at locality and administrative units related to it, this services including environment improvement /care for public health and environmental sanitation / diseases vectors control emphasis malaria vector control activities, and solid waste management.

2- Curative services
There are (2) teaching hospitals (Elban jaded hospital, Elsalam hospital) and many health centers.
3. Primary Health

Educational situation:-

- There are “61” basic schools in the study area and (176) illiteracy classes.
  - 10 Secondary school.
  - 8 Governmental kinder gartens.
  - 8 Combony school in addition

Water supply:
The main drinking water sources come from subterranean water, and some wells

1. “35” wells out of net.
2. “4” pumping stations.
3. “5” wells within the net.

(Linked with water pipes, averages of water consumtion vary from area to another in the locality.

Religious institutions:-

- 58 mosques
- 48 of khalawis
- 138 of Zawayas
- 86 Women faithful houses.
- 26 Church's.

○ There are “16” Sports and cultural clubs.

Roads: - There “9” well designed road. In addition to other under execution.

Markets:

1. Elwhda elweatanya market.
2. Elzaraib.
3. ELimtidad-Squars, and some suggested new markets.
Financial resources:-
1. Locality depends on its own financial resources and returns and commercial licenses, rent of kiosks in markets and other new markets.
2. Cattle's and sheep's.
3. Transferred fees from taxes and customs.

Police stations and courts:-
1. Elhaj Yousif police station.
2. Elhaj Yousif west police station under execution.
3. Comprehensive security spreading sites.
4. Elhaj Yousif district court.
5. Elhaj Yousif attorney.
6. Courts of Sheikhs -Provosts and Sultan

Materials and Methods

This is a descriptive study conducted in 30 schools out of 64 schools in the study area, including Basic and Higher secondary schools (governmental schools) in the study area, using the flowing materials and methods:

1. Interview questionnaires
To obtain the information and data related to schools sanitation three standardized questionnaires were developed and used including:
   1. Schools questionnaires
   2. Chief Teachers Interview and Questionnaires
   3. Observation checklist.

The questionnaires contained questions on drinking water availability, types of sources, storage vessels and cups used for Teachers and Pupils/students drinking. Also including questions on sanitation and Excreta disposal facilities at schools, how many, cleanings and healthy and safety use, and also school waste management and disposal practices.
2. Water samples collection
To assess the quality of drinking water, the Bacteriological and chemical quality of water at Schools were investigated through test for E.coli and thermo tolerant (fecal) coli form Bacteria and ion, chloride and nitrates for the main ground water sources, and physical analysis for turbidity, and residual chlorine tests. The sample were collected from the selected 30 schools, 60 samples were collected 30 from the taps and 30 from the storage vessels.

2.2. Bacteriological Analysis.
The bacteriological tests were conducted at the National Health Laboratory, food and water bacteriology department for a period of one month.
For Identifying the E.coli and Thermo tolerant (fecal) Coli form Bacteria the Filtration Membrane Methods (MF) was used.

Samples Collection and Storage:
The samples were collected from the taps and the storage vessels at the schools. Glass bottles used for water sampling with a capacity of 100 ml, fitted with ground glass stoppers and stored in a light proof insulated box containing melting ice or ice-packs with water to ensure rapid cooling.

Filtration Membrane Methods (MF)
All of the griddled membranes are made from cellulose nitrate, a material that assures excellent retention and optimum colony growth. The various colors allow the one to be chosen which gives the best contrast to the colonies that are to be counted.
The membrane filter of the appropriate pore size is placed in a filter holder, and the sample is filtered. In the process microorganisms in the test sample are retained on the filter surface by the screening action of the membrane filter. Growth inhibitors can be removed by flushing the holder with sterile water following filtration. Afterwards, the membrane filter is placed on a culture medium and incubated. Nutrients and metabolites are exchanged through the pore system of the membrane filter. Colonies, which have developed on the
membrane filter surface during incubation, are counted and related to the sample volume.

**Filtration procedure**

1. The filtration apparatus consists of a base supporting a porous disk under a graduated funnel. Sterilize the apparatus and two extra funnels by autoclaving. Then connect the base to a vacuum source.

2. Procure from a commercial source filter membranes of high quality, control grade, 47mm in diameter and 0.45µm of pore size.

3. Remove the funnel from the apparatus and with flamed and cooled flat-ended forceps grasp the edge of a sterile membrane and place it, grid side up, over the porous disk. Replace the sterile funnel securely on the filter base.

4. While the vacuum is still turned off, pour or pipette the requisite volume of the water sample into the funnel. The volume should be chosen so that the colonies to be counted on the membrane will number between 10 and 100. For chlorinated waters, filter a 100ml volume. For unknown waters, filter a range of different volumes smaller than 10ml, but add at least 20ml sterile water to the filter before addition of the sample to ensure dispersion of the bacteria over the membrane.

5. Filter the sample slowly through the membrane by applying a vacuum of about 500 mm of mercury. Stop the evacuation as soon as the sample has been filtered so that as little contaminated air as possible is drawn through the membrane.

6. Remove the funnel and aseptically transfer the membrane, keeping its upper side upwards, onto a sterile paper pad saturated with selective indicator broth or onto a plate of selective indicator agar medium. Ensure that no air bubbles are trapped between the membrane and the medium. The absorbent paper pads should be free from toxic substances, approximately 1mm thick and of at least as great a diameter as the membrane. They can be sterilized in foil-wrapped bundles by autoclaving for 20min at 1210C. Place the
pads in separate sterile Petri dishes before soaking with the special membrane medium. Pour off any excess medium from the saturated pad either before or after the membrane is in position so as to prevent the erroneous formation of confluent growth on the membrane.

7. Incubate the plates holding the membranes under appropriate conditions. Those with absorbent pads must be held in polythene bags or airtight tins containing wads of cotton wool moistened with water to prevent the pads drying out.

8. After incubation, immediately count the characteristic colonies in a good light and with the aid of a magnifying glass. Express the result as the number of indicator bacteria per 100ml of water sample.

(Tripoli, 2007).

Presumptive coli form test by filtration:

For these test the membrane are cultured on pads soaked with membrane lauryl sulphate broth, or equivalent medium (as shown in Table 7), which is inhibitory to many non-coliform bacteria and on which, because it contains lactose and phenol red, the coliforms grow as yellow-coloured colonies.

1. Filter the water sample as directed above.

2. Incubate the membranes on pads soaked with membrane lauryl sulphate broth first for 4h at 300°C and then for 14 h at 370°C.

3. Immediately on removal from the incubator, count all the yellow colonies irrespective of size and, with reference to the volume of water filtered, calculate the number of presumptive coliform bacteria per 100ml of sample.

(Tripoli, 2007).

Confirmed coli form and E. coli test by filtration:

As some non-coli form bacteria that produce acid but not gas from lactose can form yellow colonies in the presumptive coli form test, the number of yellow colonies that are coli forms must be confirmed by the demonstration of gas formation at 370°C and the number that are E. coli by the demonstration that
they can form acid and gas from lactose at 440C and indole from tryptophan at 440C.

1. Subculture every yellow colony or a sufficient representative number of them, from the membranes cultured for the presumptive coliform count, each into two tubes of lactose peptone water with phenol red containing an inverted, medium filled Durham tube, and a tube of tryptone water.

2. Incubate one of the tubes of lactose peptone water at 370C and the other at 440C; after about 6h, subculture growth from the lactose peptone water incubated at 370C onto a plate of nutrient agar; incubate this plate at 370C and re-incubate the tube at 370C.

3. After 24h incubation; (a) do an oxidase test on colonies on the nutrient agar plate; (b) add a few drops of Kovac's (indole) reagent to the tryptone water culture and look for the development of a pink colour denoting indole formation; (c) inspect the lactose peptone water cultures for the formation of acid (yellow colour change) and gas, re-incubating those that are negative for re-examination after a further 24h at 370C.

Colonies on membranes are confirmed as being coli form bacteria if they are oxidase negative and form acid and gas in lactose peptone water incubated at 370C. The oxidase test is required to exclude those Aeromonas species that form acid and gas from lactose but are oxidase positive.

Yellow colonies on membranes are confirmed as being E. coli if they are oxidase negative, form acid, and gas in lactose peptone water incubated at 440C and form indole in tryptone water incubated at 440C.

4. From the results, calculate the confirmed coli form count and confirmed E. coli count per 100ml water sample. (Tripoli, 2007).

2.3. Physical analysis.
Turbidity and residual chlorine tests were conducted.
The data of the chemical quality Chloride, Iorn of the wells was obtained from Sharg ALNiel Locality, Water safety department records for 2008.
MEMBRANE FILTRATION TESTS

All of the griddled membranes are made from cellulose nitrate, a material that assures excellent retention and optimum colony growth. The various colours allow the one to be chosen which gives the best contrast to the colonies that are to be counted.

The membrane filter of the appropriate pore size is placed in a filter holder, and the sample is filtered. In the process microorganisms in the test sample are retained on the filter surface by the screening action of the membrane filter. Growth inhibitors can be removed by flushing the holder with sterile water following filtration. Afterwards, the membrane filter is placed on a culture medium and incubated. Nutrients and metabolites are exchanged through the pore system of the membrane filter. Colonies, which have developed on the membrane filter surface during incubation, are counted and related to the sample volume as shown in Figure 8.

Filtration procedure

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7. Incubate the plates holding the membranes under appropriate conditions. Those with absorbent pads must be held in polythene bags or airtight tins containing wads of cotton-wool moistened with water to prevent the pads drying out.

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(Tripoli, 2007).
**Presumptive coli form test by filtration:**
For these tests the membrane are cultured on pads soaked with membrane lauryl sulphate broth, or equivalent medium (as shown in Table 7), which is inhibitory to many non-coli form bacteria and on which, because it contains lactose and phenol red, the coli forms grow as yellow-coloured colonies.

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(Tripoli, 2007).

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3. After 24h incubation; (a) do an oxidize test on colonies on the nutrient agar plate; (b) add a few drops of Kovac's (indole) reagent to the tryptone water culture and look for the development of a pink colour denoting indole
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Yellow colonies on membranes are confirmed as being E. coli if they are oxidase negative, form acid, and gas in lactose peptone water incubated at 440C and form indole in tryptone water incubated at 440C.

4. From the results, calculate the confirmed coli form count and confirmed E. coli count per 100ml water sample.

(Tripoli, 2007).

**Physical and chemical Analysis**
The samples were field tested for Turbidity and residual chlorine.

The data for chemical quality Chloride, Iron of the wells was obtained from Sharg ALNiel Locality, Water safety department records for 2008.
Chapter 3
Results
Results

The study was conducted to assess the schools sanitation facilities and the impact on schools pupils /students health through identifying and asses the drinking water quality risk point at schools, determining the availability, types/function and use of the sanitation / latrines at schools and assessing the awareness and solid waste management practices at schools.

The hypothesis is that the sanitary conditions in Alhaj Yousif schools are woefully inadequate. Water supply, sanitation and hand washing facilities are either non-existent, too few or inadequate due to poor maintenance of water systems and toilets or latrines.

Questionnaires and interview results:

For identifying and assessing the drinking water quality risk point at schools, Table No (1), (2) & (3) show that 73.3% of the schools with drinking water facility, 70.5% of the schools with water pipes supply, 57.7% of the schools using Zeers (Clay Jar) for drinking water storage and the others using 6.75% Barrel, 23.3% using both Zeers and barrels, 3.3% using Zeers, Barrels and Coolers, and 10% using other storage vessels.

Determining the availability, types/function and use of the sanitation / latrines at schools, tables (4), (5), (6), (7) show that 96.7% of the schools with toilets, all the schools have separate toilets for the boys and girls and teachers and school staff, 83.3% of the toilets were Ventilated Improved pit latrines (VIP), 13.4 Septic tanks and 3.3% Traditional pit latrine, and 40.5% of the toilets cleaned by students and 33.3% by cleaners.

The tables (8),(9), concentrated on the schools waste Management practice and show that 60% of the schools with waste collection and storage system, 46.7% of the schools burned the waste at schools.

The data obtained from teachers questionnaire in tables (10) show that 43.3% of the School water facility monitored, in table (11) 70% of the teachers trained
on Hygiene practices, in table (12) 46.7% of the Schools with partners and other collaboration institution on water and sanitation at their schools.

**Water samples Analysis results:**
The Bacteriological tests results in table (14) & Fig No.(3) show that 58.3% of the tested samples were positive Thermo tolerant Coli form, 41.7% with positive presumptive E.Coli Test and 21.7% with positive confirmatory E.coli Test.
The physical tests results in, Fig No.(1-A,1-B) show that 67.15% of the samples with chlorine residual less than 0.5 Mg/L, Fig No. (2) show that 100% of the tested samples were of less than 5 NTU Turbidity level. chart No. (4) Show level of Iron, Fluoride and Nitrate in the tested Wells.
Table No. (1) Availability of water facilities in School

<table>
<thead>
<tr>
<th>Availability</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>available</td>
<td>22</td>
<td>73.3</td>
</tr>
<tr>
<td>Non-available</td>
<td>8</td>
<td>26.7</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>100</td>
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</tbody>
</table>

Table No. (2) Type of water facility in school

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>Frequency</th>
<th>Percentage (%)</th>
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<tbody>
<tr>
<td>Water pipes</td>
<td>22</td>
<td>70.5</td>
</tr>
<tr>
<td>Other facility</td>
<td>8</td>
<td>29.5</td>
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### Table No. (3) The Type of Drinking Water Storage vessels

<table>
<thead>
<tr>
<th>Type of vessel</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeer</td>
<td>17</td>
<td>57.7</td>
</tr>
<tr>
<td>barrel</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>Others</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Zeer &amp; Barrel</td>
<td>8</td>
<td>26.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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### Table No. (4) Toilets Availability at Schools

<table>
<thead>
<tr>
<th>Availability</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available</td>
<td>29</td>
<td>96.7</td>
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<tr>
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<td>3.3</td>
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</table>
Table No. (5) Availability of separate toilets for boys & girls

<table>
<thead>
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<th>Availability</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>Not available</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
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<td>100</td>
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Table No (6) the availability of hand washing facilities in toilets

<table>
<thead>
<tr>
<th>Availability</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available</td>
<td>17</td>
<td>56.7</td>
</tr>
<tr>
<td>Not available</td>
<td>13</td>
<td>43.3</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>
Table No (7) Type of toilets at the Schools

<table>
<thead>
<tr>
<th>Type of toilets</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Pit latrine</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>VIP</td>
<td>25</td>
<td>83.3</td>
</tr>
<tr>
<td>Septic tank</td>
<td>4</td>
<td>13.4</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
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</table>

Table No (8) Availability of wastes collection storage system in schools

<table>
<thead>
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<th>Availability</th>
<th>Availability</th>
<th>Percentage (%)</th>
</tr>
</thead>
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<tr>
<td>Available</td>
<td>18</td>
<td>60</td>
</tr>
<tr>
<td>Not available</td>
<td>12</td>
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</tr>
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</table>
Table No (9) Waste disposal systems in schools

<table>
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<th>Frequency</th>
<th>Percentage (%)</th>
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<tbody>
<tr>
<td>Burned</td>
<td>14</td>
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<tr>
<td>Transported to the dumping area</td>
<td>10</td>
<td>33.3</td>
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<tr>
<td>Others</td>
<td>6</td>
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Table No (10) availability of water quality monitoring system

<table>
<thead>
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<th>Availability of the system</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available</td>
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<td>43.3</td>
</tr>
<tr>
<td>Not available</td>
<td>17</td>
<td>56.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
<td><strong>100</strong></td>
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</table>
Table No (11) The Schools teachers trained on water & hygiene

<table>
<thead>
<tr>
<th>Trained Teachers</th>
<th>Frequency</th>
<th>Percentage (%)</th>
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<tbody>
<tr>
<td>Trained</td>
<td>21</td>
<td>70</td>
</tr>
<tr>
<td>Not trained</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
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</table>

Table No (12) Availability of collaborative institutions working with schools on water and sanitation

<table>
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<th>response</th>
<th>Frequency</th>
<th>Percentage (%)</th>
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</thead>
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<tr>
<td>yes</td>
<td>14</td>
<td>46.7</td>
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<td>No</td>
<td>16</td>
<td>53.3</td>
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<tr>
<td>Total</td>
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Table No (13) Availability of water & sanitation program in the school

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<th>Percentage (%)</th>
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</thead>
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<td>43.3</td>
</tr>
<tr>
<td>No</td>
<td>17</td>
<td>56.7</td>
</tr>
<tr>
<td>Total</td>
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<td>100</td>
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</tbody>
</table>

Table No (14) Bacteriological water quality in schools

<table>
<thead>
<tr>
<th>Test</th>
<th>Confirmed E.Coli Test</th>
<th>E.Coli Test</th>
<th>Presumptive E.Coli Test</th>
<th>Presumptive %</th>
<th>Thermo tolerant coli form test</th>
<th>Thermo tolerant %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>count</td>
<td>%</td>
<td>count</td>
<td>%</td>
<td>count</td>
<td>%</td>
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<tr>
<td>Positive</td>
<td>13</td>
<td>21.7</td>
<td>25</td>
<td>41.7</td>
<td>35</td>
<td>58.3</td>
</tr>
<tr>
<td>Negative</td>
<td>47</td>
<td>78.3</td>
<td>35</td>
<td>58.3</td>
<td>25</td>
<td>41.7</td>
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<td>100</td>
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</tbody>
</table>
Figure no.1-A: Results of chlorine and Turbidity levels of drinking water

Figure no.1-B: Results of chlorine and Turbidity levels of drinking water
Figure .No.2: Results of Water Bacteriological tests

Figure .No.3: the result of the Water chemical tests
Chapter 4
Discussion

All schools and educational facilities should have adequate water, sanitation and hygiene facilities to ensure the health of their pupils/students and staff. Access to adequate sanitation facilities is essential for children, as their right to health and survival depends on it. The dangers of the spread of diseases increase greatly when large numbers of children are brought together on a daily basis at school. It is therefore critical that hygiene practices and the necessary toilet facilities are made available at school.

This study was conducted to assess the schools sanitation facilities and the impact on schools pupils/students health through identifying and assessing the drinking water quality risk point at schools, determining the availability, types/function and use of the sanitation/latrines at schools and assessing the awareness and solid waste management practices at schools.

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve a drinking-water quality as safe as practicable. “All peoples, whatever their stage of development and social and economic condition, have the right to have access to drinking-water in quantities and of a quality equal to their basic needs.” WHO 1997. The MDGs aim to Halve, by 2015, the proportion of people without sustainable access to safe drinking water (UN 2008). For water sources and availability in schools, most of the schools with drinking water facility, 80% of the schools in the area with drinking water sources, 70.5% of the schools with pipes water supply, these results indicate that the schools authorities have some responsibility for providing safe and adequate water supply form schools from the municipal water corporation. Source of water supply must be capable of supplying enough water for the School members. (WHO, 1993). The key factors to provide safe drinking water are the conditions...
and practices of water collection, storage and the choice storage containers /vessels (WHO, 2002), 56.75% of the schools are using Zeer (Clay Jar) for drinking water storage and the others using Barrel, or both Zeer and barrels, and using other storage vessels, most of these vessels are traditional vessels or made of plastic or metal, they need continuous cleaning and to be with cover all the time. The availability of Ladles/cups for water handling from the vessels is most important to prevent water from contamination, 83.3% of schools with Ladles/cups with handle for drinking water.

The principal risk associated with water community supplies is that of infectious diseases related to faecal contamination. The microbiological examination of drinking water emphasizes assessment of the hygienic quality of the supply. This is an important element of quality control. In most circumstances, concentrations of thermo tolerant coli forms are directly related to that of E. coli. (WHO, 1997). The Bacteriological water quality tests results indicate that 58.3% of the tested samples were positive Thermo tolerant Coli form, 41.7% positive presumptive E.Coli Test and 21.7% positive confirmed E.coli Test. For all water directly intended for drinking E. coli or thermo tolerant coli form bacteria, Must not be detectable in any 100-ml sample (WHO 2006).

In most circumstances, concentrations of thermo tolerant coli forms directly related to that of E. coli. Their use in assessing water quality is there fore considered acceptable for routine purposes, but the limitations with regard to specificity should always be borne in mind when the data are interpreted. If high counts of thermo tolerant coli forms found in the absence of detectable sanitary hazards, additional confirmatory tests specific for E. coli carried out.

Water physical characteristics can be divided in to Turbidity, temperature, color, taste and Odour, solids and conductivity. Water turbidity levels are accepted for all the schools water (less than 5 NTU). Turbidity is measure of the ability of water to scatter light and is caused by small particles in the water (Morris, etala
Drinking water should be free from turbidity. At level of fluoride in drinking water greater than 5 mg/L, the consumer may suffer from floursis, which is hardening of the bones and mottling of the teeth. (Morris, et al. 1989). The study indicates the level of the fluoride in the schools area is accepted less than (1.5mg/L) (Sudanese Standards and Metrology Organization 2002). Drinking-water Standard ICS 13. 060.00. The Iron concentration in the schools area is seems to be high but not more than the acceptable standard (.3 mg/L).

Khartoum state, Aharg Elnil Locality has regular water monitoring system by the Locality Environmental Health department, Water quality monitoring unit. The inadequate and insanitary disposal of infected human faeces leads to the contamination of the ground and of sources of water. Often it provides the sites and the Opportunity for certain species of flies and mosquitoes to lay their eggs, to breed, or to feed on the exposed material and to carry infection. It also attracts domestic animals, rodents and other vermin which spread the faeces and with them the potential for disease. In addition, it sometimes creates intolerable nuisances of both odour and sight. There are diseases related to excrete and waste water which commonly affect people in the developing countries and subdivided into communicable and non-communicable diseases (WHO 1992). The various methods of human wastes disposal will be described focusing on the most common and acceptable types of latrines for use in the area. To assess availability/ types/function and use of the sanitation / latrines at schools, the study show that 96.7% of the schools with toilets, 43.35% of the Schools with clean toilets, 73.3% of the toilets with doors and easy open and lock, 56.7% of the toilets attached with hand washing facilities, 63.3% of the schools with toilets have separate toilets for boys and girls and the teacher and school staff. A focus on gender differences is of particular importance with regard to sanitation initiatives, and gender-balanced approaches should be encouraged in plans and structures for implementation. The types of latrines that have been considered for comparison include: Pour-flush latrines (water based latrines), ventilated
improved pit latrines, improved traditional pit latrines, aqua privies and composting (ecosan) latrines. (UNICEF / WES 2008). 83.3% of the toilets were Ventilated Improved pit latrines (VIP), 13.4% Septic tank and 3.3% Traditional pit latrine. VIP latrines are very easy to maintain and clean. Cleaning should be done regularly. The repairs of any part of the latrine are easy because it can be done by the local people using locally available materials. (Nicholase 1992).

40.5% of the toilets cleaned by students and 33.3% by cleaners. Keeping clean and disposing of human waste (feces and urine) are necessary for good health. If they are not taken care of in a safe way, our feces and urine can pollute the environment and cause serious health problems, such as diarrhea, worms, cholera, and bladder infections (UNDP 2005).

The quality of solid waste collection and transportation operations depends on an appropriate preparation and storage of waste and its presence in the place, on the day and at the time established by the urban cleaning body responsible for collection. Citizens participation in this operation is therefore of great importance. (Ministry for the environment, Brazil and others 2008).

Concentrated on the schools waste management practice we find that 60% of the schools with waste collection and storage system, 46.7% of the schools burned the waste at schools. Domestic waste collection services to each building should be regular, always on the same days of the week and at the same times. The interval between domestic waste generation and its final disposal should be of no more than one week in order to avoid bad odours and the proliferation of flies, rodents and other animals attracted by the waste. Schools generate waste in the form of paper, cardboard and plastic materials as well as organic waste, all of which has to be collected for disposal. For this, suitable containers must be provided in each classroom, latrine, and in various places in the courtyard. When there is no organized system for waste collection in the local community, the following actions could be taken:
• Paper waste can be buried in the ground or burned in an incinerator made from an oil drum.
• Organic materials can be composted, for instance in big cement rings, and used as fertilizers for trees and plants in the school compound.
• Plastic waste can be collected and buried or in some cases recycled

Life skills-based hygiene education seeks to combine the teaching of hygiene principles with children’s developing experience of life at home, at school and in the community. For WASH in Schools to succeed, all students and school staff must practice proper hygiene and sanitation behaviors. 70% of the teachers teaching Hygiene practices through the general curriculum and Therefore, wherever possible, hygienic and sanitation practices must be built into the school curriculum as a permanent feature (IRC 2007). To sustain or develop

Water and sanitation in schools, needs strong collaboration with the related institutions and the community commitment with a good partnership to the supported organizations 46.7% of the Schools with partners and other collaboration institution on water and sanitation at their schools. Water and sanitation in schools needs strong collaboration with the related institutions and community commitment with a good partnership.
Conclusion

Khartoum State, Sharag Alnil Locality, AlHaj Yousif area is a suburban area connected by the municipal water supply, included in the state solid waste management program. The study results show that there are schools out of the public water network using other sources (dug wells) which may need regular monitoring and safe sanitary conditions. Majority of the schools using (VIP) as facility of human excreta disposal, few schools with septic tank, no Conventional sewerage systems in the area, both sex boys and girls with separate toilets in the schools and other toilets were available for teachers and school staff. Although there is a solid waste management system in Khartoum state but not all the schools are involved in this system, some schools burn the waste near or beside the school area. Teachers teach Hygiene practices through the general education curriculum, at the locality level also the department of Health education trained many teachers on hygiene and behavior change.

In Alhaj Yousif area there are many charity organizations working in the field of capacity building and human development, some schools get support from these Organizations and the local community in the means of establishing rooms, toilets.

The knowledge and life skills required to maintain a healthy life usually learnt from families, neighbors and school in childhood. “Primary school children of today will be the adults of the future. Therefore, national and sectoral policies and budgets must prioritize School Sanitation Hygiene Education in terms of the needs. If all schools are to have safe water, sanitation, and hygiene education, current best practices must scale up healthy and safe school environment.
Recommendations

Refer to the study findings the following recommendations are drawn:

1. Scale up schools drinking water availability, the municipal water network involve the schools out of the system to keep the availability and bacteriological quality of drinking water,
2. Regular water sampling and analysis is a must for the schools water sources and storage vessels to monitor the Bacteriological, physical and chemical drinking water quality
3. Improve the schools sanitation status: availability, suitable types and functioning, additional numbers of toilets needed with proper establishment and maintenance.
4. Involve all the schools in the municipal solid waste management system with attention to the waste collection and storage in schools and
5. Implement Water and sanitation program to cover all the schools including training of teachers on water and sanitation program; promote students/ pupils skills and practices.
6. Strengthen schools partnership and community involvement in schools water and sanitation programs.
References:


2. Nyang'echi George Nicholas 1992, Management of Solid Waste and Liquid Wastes, African Medical and Research Foundation


4. Guy Howard, Jamie Bartram 2003, Domestic Water Quantity, Service Level and Health, World Health Organization

5. Ingvar Anderson 2005, Sanitation and Cleanliness for a Healthy Environment, Hesperian Foundation and UNDP.


11. Lizette Burgers 2000, Background and rationale for School Sanitation, UNICEF.
    Rose Lidonde, WEDC, UK 2004, Scaling up School Sanitation and Hygiene Promotion and Gender concerns
19. UNDP 2006 Mainstreaming Gender in Water Management


31. World Health Organization 2004, Water Treatment and Pathogen Control

32. United Nations Environment Programme, (2005), Solid Waste Management (Volume I)

Appendixes
Appendix (1)

University of Khartoum
Faculty of Public & Environmental Health
Sanitation risk point assessment at schools in Khartoum state, Sharg Elneel Locality (Elhaj yousif administration unit)

Checklist for Schools

The data needs to be collected from governmental Schools using a Stratified sample survey and covering all categories (basic, higher secondary)

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<thead>
<tr>
<th>State</th>
<th>District</th>
<th>Block No.</th>
</tr>
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</table>

<table>
<thead>
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<table>
<thead>
<tr>
<th>Name of the School</th>
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</table>

<table>
<thead>
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<th>Category of school: 1/ Basic school</th>
<th>2/ High secondary school</th>
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</table>

<table>
<thead>
<tr>
<th>Type of School</th>
<th>1/ Gender School</th>
<th>2/ Co educated School</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>No of students/pupils in School</th>
<th>Male</th>
<th>Female</th>
<th>No of teachers in the School</th>
</tr>
</thead>
</table>

**Water supply & quality:**

1. Is there water facility within the school premises? 1. Yes 2. No
2. Is water available all of the time at the school? 1. Yes 2. No
3. Is there a functioning water point within the school area? 1. Yes 2. No
4. Is the water apparently of drinking quality at the water point? 1. Yes 2. No
5. Is there water storage facility in the school? 1. Yes 2. No
6. Type of water storage facility
   1) Clay Jars... 2) barrels 3) Cooler 4) Others (specify)
7. Are there ladles or cups with handles used by students/pupils and teachers for taking the drinking water? 1. Yes 2. No
8. Water sampling quality:
   1. Water Bacteriological Quality Testing
   2. Water Quality at Point of Consumption
Sanitation and human Excreta disposal

1. Are there toilets in the School premises?    Yes    No

2. Provision of sanitation facility (in numbers) in School

<table>
<thead>
<tr>
<th></th>
<th>Girls</th>
<th>Boys</th>
<th>Teachers</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. If it is a co-ed school, provision of separate toilets for girls 1. Yes    No

4. Are the toilets and urinals clean? (Free from visible garbage, feacal matter on floor, smell not too bad enough to stop use, no puddles, not too many flies)

Yes    No

Comments

5. Is there water storage facility and mug inside or beside the toilets? (1.Yes/ 2. No)

6. Are the toilets easy to open or kept in lock and key in School? (1.Yes/ 2. No)

7. Is there any hand washing facility in the

8. Do teachers have separate latrines in School? 1. Yes    2. No

9. Who cleans the toilets:

10. Type of the toilets: 1) traditional pit latrine 2) VIP 3) Septic tank 4) Aqua privy 5) Sewers

Solid waste management practice

1. Who are responsible for school cleanliness?

1. Students ......Cleaners......Others

2. Is there waste s collection, storage system in the school? 1. Yes    2. No

3. Waste final disposal method?

1. Burned in the school transported to the final disposal area others

4. If three (3) specify .................................................................
Observations

1. Water storage facilities cleanings & safety.
2. Students /Pupil's water consumption.
3. Are the toilets and urinals clean? (Free from visible garbage, faecal matter on floor, smell not too bad enough to stop use, no puddles, not too many flies)
4. Schoolyard cleanliness status.
5. Waste containers and the area around.
Appendix (2)

Teachers Questionnaire

The data needs to be collected from chief teachers at all categories (Basic, Higher secondary)


3. On what day(s) is the toilet cleaned in School…………………

4. What and how is the resource generated for soaps, mugs, buckets etc?

   1. ……………………………………………………………………
   2. ……………………………………………………………………
   3. ……………………………………………………………………

5. Have the teachers of this school been trained in hygiene education? (1.Yes/2.No)  

6. Have the teachers taught anything about hygiene (safe water, household sanitation, personal hygiene? 1. Yes  2. No

7. Status of institutions associated with the school water supply and sanitation

   1. ……………………………………………………………………
   2. ……………………………………………………………………
   3. ……………………………………………………………………

8. The responsible agency for waste disposal?

9. Is there water and sanitation program in

   ………………………………………………………………………….
Appendix (3)

ritional

(health and education)

health and education

health and education

health and education

health and education

health and education

health and education

health and education

health and education

health and education

health and education

health and education

health and education

health and education

health and education

health and education
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<th>الفصل / الدراسة</th>
<th>النتيجة</th>
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<td>نعم</td>
</tr>
<tr>
<td>الفن</td>
<td>معلم</td>
<td>2/1</td>
<td>لا</td>
</tr>
</tbody>
</table>

**الملاحظات**

- 1/2: يوجدuję ماء جودة للفحص عنات.
- 1: أخذ ماء عنات تم المصدر من المدرس.
- 2: أخذ ماء عنات ماء الشرب وحفظ العيارة من المدرس.
- 3/2: أخذ ماء مرافق للدورة.
- 4: تجربة المياه في ال⸜سات في المدرسة.
- 5: تجربة المياه في الحمامات وفترات.
- 6: تجربة المياه في ال التشطيب والطريقة هي
- 7/2: تجربة المحوبيات في المرة.
- 8: تجربة المحتويات في المرة.
- 9: تجربة المحتويات في المرة.

*لم يتم تحديد البيانات:* 

- 1/2: الإداريات: 

- 2/2: الإداريات: 

- 3/2: الهالة الطلبية في المدرسة.

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*لا يوجد ملاحظات إضافية.*
لا يمكنني قراءة النص العربي من الصورة المقدمة.
لا يوجد نص يمكن قراءته بشكل طبيعي من الصورة المقدمة.