**COMPARATIVE ASSESSMENT OF WATER QUALITY STANDARD FOR EFFECTIVE LABORATORY WATER ANALYSIS IN AFRICA.**

**BY**

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**ABSTRACT**

Unsafe drinking water is one of the main concerns in developing countries. Diseases caused by contaminated water consumption and poor hygiene are among the leading causes of death in children, the elderly and people with compromised immune system. The present study aims to assess the drinking water quality of some selected drinking water sources in the chosen study area using water quality index (WQI). With the exception of pH, river water had the highest content of all the physicochemical parameters examined. Excluding dissolved oxygen in river sample, the physicochemical parameters of the water sources were generally within the World Health Organization (WHO) standards. The results of this study are beneficial for water quality management and could be used for low-cost effective water quality assessment.

**1.0 INTRODUCTION**

Water is most vital liquid for maintaining the life on the earth. About 97% water is exists in oceans that is not suitable for drinking and only 3% is fresh water wherein 2.97% is comprised by glaciers and ice caps and remaining little portion of 0.3% is available as a surface and ground water for human use (Miller, 1997). Water is essential for life. Safe, abundant water is vital to our ability to prosper and to fulfil our potential. Without it, we face a continual decline in our well-being, poverty and hunger, and increasing levels of conflict.

Across Africa, a third of us have no access to clean water, and almost two thirds no access to clean sanitation, causing widespread suffering from malaria, typhoid, dysentery and many other diseases. Apart from this effect upon our health, the loss of productivity that results from water-related illnesses holds back our progress.

The population in many African countries is growing rapidly each year, averaging 2.5% across sub-Saharan African, but the lack of safe water and sanitation reduces our economic growth at twice that rate. And a growing population must be properly fed. We need to increase our food production by half in the next twenty years. How will we achieve this without reducing the amount and quality of the remaining water resources which we will need for drinking and sanitation? Clearly, the provision of sustainable, clean water for our people is of the highest priority.

The effects of climate change make the challenge of conserving our precious water resources even more difficult. The people of Africa that are responsible for less than 5% of the pollution which has changed the planet’s atmosphere, will feel the worst of its impact in terms of increased flooding and drought. Climate change is a global problem, and it places the onus upon the global community to live up to their commitments to reduce by half the proportion of people without access to safe drinking water and basic sanitation.

Yet despite all the obstacles we face, I remain an optimist when it comes to Africa’s agricultural development and to water sustainability.

The introduction of new forms of irrigation pioneered by African scientists and research institutions has the potential to transform the way staple foods are cultivated. Today, only 10% of Africa’s cultivated land is irrigated. Imagine what we can do if this percentage is increased in a way which also does not overburden our water supplies.

We need to make more use of fertilizers to feed nutrient deficient soils, and of modern crop varieties and new farming techniques to improve yields. We can see already what can be achieved with determination, vision and partnership.

With the right policies and commitment, Africa has the chance to match, indeed better the Asian agricultural miracle of the last generation. Better because we can do so in an environmentally sustainable way, which takes fully into account the fact that 80% of Africans are dependent in some way on agriculture.

Sustainable supplies of water, its better management and protection are the key to this success – just as increased agricultural productivity holds the key to spreading prosperity and our other development goals.

This report relies upon the collective knowledge of scientists from across Africa, detailing how we can improve our capacity to tackle these challenges by establishing new centres of scientific excellence and by bringing together the best minds in science with governments to ensure water sustainability.

I have no doubt of the scale of the challenge, but I am also optimistic that with vision and will, we can encourage governments across Africa to adopt these solutions and put them into practice.

**2.0 LITERATURE REVIEW**

**PROVISION OF WATER RESOURCES IN AFRICA**

sufficient quantity forms the cornerstone for achieving these Millennium Development Goals.

In 2009, Africa’s population exceeded 1 billion2 and continues to increase at a rate of 2.4% annually. Of this population, 341 million lack access to clean drinking water,3 and a further 589 million have no access to adequate sanitation.4 In both cases, increases in coverage are not keeping pace with population growth, which means it will be unlikely that the 2015 Millennium Development Goals will be met.

It is estimated that around half of all patients occupying African hospital beds suffer from water-borne illnesses due to lack of access to clean water and sanitation. This is reducing the overall health and productivity of the adult workforce.5 Water-borne diseases like typhoid, cholera and dysentery are among the major causes of mortality and morbidity in Africa. Lack of safe water and sanitation costs sub-Saharan Africa around 5% of its Gross Domestic Product (GDP) each year.6 Households in rural Africa spend an average of 26% of their time fetching water; generally, women are burdened with this task.

The number of people experiencing starvation has increased due to prolonged drought between 2007 and 2009 in many countries. In 2005, at least 280 million people were undernourished, with most of these living in Sub-Saharan Africa.7 Demand for water to grow food has increased as a result of the increasing population and Africa has not been able to produce enough food. Over the past 50 years, cereal yields in Africa have stagnated whilst population has increased.8 A lack of investment in irrigation infrastructure and new technologies means that Africa has some of the lowest water-to-food conversion rates in the world.

The water resources that Africa has are being degraded due to high demand and untreated waste water entering the environment from industry and domestic sources. Adaptation and planning of water resources is difficult, as many African countries have no established water quality monitoring programs. Most of the rivers and water courses are non-gauged and the rural and per urban water supply is not considered to be an essential part of most water treatment systems. Water pollution statistics are limited as adequate analytical laboratories are scarce. There has been a lack of focus on water as a critical resource and therefore this sector has seen substantial under-investment. Above all, the absence of a structured framework for water governance is hindering effective water management.

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**Where is the water?**

Africa as a continent appears to have an abundance of water; it has 17 rivers, each with catchments over 100,000 km2, more than 160 lakes larger than 27 km2, vast wetlands and limited, but widespread, groundwater. Rainfall similarly is plentiful, with Africa’s annual average precipitation being at a level comparable to that of Europe and North America.9 Withdrawals of water in Africa for its three main uses – agriculture, domestic, and industry – is low, estimated to be only 3.8% of total annual renewable water resources.10

However, Africa is a continent with large disparities in water availability between sub-regions. About 50% of Africa’s total surface water is concentrated within a single basin – the Congo river basin – and 75% of total water resources are concentrated in just eight major river basins.11 The countries with the highest available freshwater per capita include the Democratic Republic of Congo, with around 250,000 m3 per capita per year. In contrast, Burundi and Kenya have only around 840 and 950 m3 freshwater per capita per year, respectively.

Figure 1 shows the extreme spatial variability of rainfall across the continent, from the humid tropics to the arid Sahara. There are, of course, substantial differences in rainfall at different times of the year and, in some regions, it also varies from year to year and from one decade to the next.

## Water stress and scarcity

The disparity in water resources across Africa means that a quarter of all people are experiencing water stress (defined as between 1000 and 1500 m3 per capita per year).14 With populations increasing, water scarcity (less than 1,000 m3 per capita per year) is emerging as a major development challenge for many African countries.

Water scarcity was experienced in 10 African countries in 1995: Algeria, Burundi, Cape Verde, Djibouti, Egypt, Kenya, Libya, Malawi, Rwanda and Tunisia. Projections indicate that the situation will worsen by 2025, 14 countries will suffer water scarcity and a further 11 countries will suffer water stress.15 In a few years, at the current rate of water demand, almost all sub-Saharan African countries will be below the level at which water supply is enough for all. Even worse, most of them will be in a state of water-stress or scarcity.

The amount of water available is a key concern in countries racing towards their physical limit of available fresh water. In other countries, the rapid population growth and the expansion of urban settlements, industry and commercialized agriculture, is adding extra pressure on water resources that are also degrading in quality.

## Water quality

Water quality is impacted both by natural processes, such as seasonal trends, underlying geology and hydrology, weather and climate, and by human activities, including domestic, agriculture, industry and environmental engineering. 75% of Africa’s drinking water comes from groundwater16 and is often used with little or no purification. Water contaminated by microbiological pollutants spread diseases such as dysentery, cholera and typhoid. Chemical contaminants, including those naturally found in the underlying bed rock, can also cause disease and developmental problems, and can adversely affect agricultural yields and industrial processes. A detailed knowledge of water quality is essential so that drinking water can be adequately treated and the contamination of its sources can be prevented.

The United Nations Environment Programme (UNEP) has recently set up GEMStat database, dedicated to water quality.17 The database includes data for all regions in the world including Africa, and contains information about physicochemical parameters (e.g. pH), nutrients, major ions (including metals), organic matter and organic contaminants, together with microbiological and hydrological data. However, the data collected for Africa is only limited to specific regions and in many cases does not give a detailed assessment of the sources of ground and surface water.

Improvement in coverage is needed in parts of the globe, particularly in Africa. Where the quality of water is being measured, a worrying picture is emerging. Many important water bodies, which provide water for drinking, washing and irrigation for many thousands of local inhabitants, are showing unacceptable levels of potentially toxic substances. These include heavy metals, persistent organic pollutants (POPs) and biological contaminants. These pollutants originate from a variety of sources, including local industries and domestic waste water. It is clear that, without increased monitoring, it will be difficult to protect water quality and implement preventative policies and practices.

## Increasing water efficiency

Access to water is a major determinant of land productivity and the stability of crop yields. Increasing productivity from rain-fed agricultural land should initially be a priority, as existing knowledge and technologies can be applied to aid areas where crop yields are still below average.

Approaches that require minimal external inputs, by exploiting biological and ecological processes, include: conservation tillage, green manure cover crops, and the introduction of crop varieties that are more tolerant of pests, diseases and drought. Since the introduction of cover crops, no-till acreage has increased by nearly 40%. This approach reduces the demand for energy and water by reducing evaporation of moisture from the soil, raising its carbon content and improving its structure, increasing earthworm populations and combating wind and water erosion. However, lack of information on agro-ecology and the high demand for management skills are major barriers to the adoption of sustainable agricultural techniques in Africa.

Where appropriate, an increase in the area of irrigated land is also desirable, as irrigated land productivity can be more than double that of rain-fed land.22 In sub-Saharan Africa, only 4% of the area in production is under irrigation, compared with 39% in South Asia and 60% in India. With climate change leading to rising uncertainties in rain-fed agriculture, investment in water storage infrastructure and irrigation systems could ensure crop yields should rainfall become more erratic.

The introduction of improved crop varieties generated through conventional breeding or genetic modification could also help to boost yields and improve the quality of many foodstuffs, as it has in other parts of the world. The higher crop yields obtained through genetic modification are believed to have saved millions of square miles of wildlife habitat from conversion to agricultural use. In the past, most biotechnology research occurring outside Africa was driven by commercial interest, which was of little benefit to small or poor consumers and did not suit Africa’s wide ranging ecosystems. This is beginning to change, with work being carried out, for example, on cowpea23 and maize,24 plus a number of other varieties of crop that are nutritionally important to African communities.

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| **ENVIRONMENTAL HEALTH** |

Environmental monitoring is essential if we are to identify sources of contaminants and build strategies to avoid these entering water resources that may be used for human consumption. Good environmental monitoring, operating within a robust legislative framework, is an essential prerequisite to achieve this. The first step is an assessment of the present status of the aquatic environment. Effort can then be focused on the restoration and protection of environmental health.

In order to build the capacity to protect environmental health, investment needs to be made in suitable hardware (technology that is fit for purpose including low technology options). However, the training of suitable personnel, together with the development of systems for data validation and quality assurance, are equally important. This requires people to operate and maintain the instrumentation and others to interpret the data, formulate policy and implement strategy. This is achievable through the identification and support of ‘Centres of Excellence’ within the region in question.

In determining a strategy for the protection of environmental health of the African continent, it is essential to involve and engage the communities who will benefit most from the rewards of a healthy environment. The equipment will need to be robust, low-cost and easy to maintain. The use of local or indigenous knowledge, where appropriate, will increase the probability of acceptance and success in the drive for the protection of the health of both humans and ecosystem in Africa.

**Increasing analytical capacity in Africa**

The increasing growth in the African population, combined with a lack of stringent environmental safeguards, has given rise to serious concern about water quality, and the associated threats to human health and the environment. If Africa and its research scientists are to embrace the recommendations of this report, increasing Africa’s capabilities and capacity in analytical chemistry is imperative. In order to support chemical monitoring and management activities such as those discussed here, there is an urgent need for more personnel who are scientifically qualified and technically trained in relevant advanced analytical techniques. These include, for example, modern capillary gas chromatography (GC) methods incorporating detection either by electron capture (EC) or mass spectrometry (MS). Thus, it is essential to create and support centres of excellence in analytical chemistry, with a critical mass of experts, in African universities.

The status of instrumentation in African Higher Education institutions is a grave problem which urgently requires addressing. Governments need to provide funds to enable universities to access and maintain the required equipment, and also to facilitate continued training of researchers. Optimisation of resources is crucial if funds are to be used wisely, and national and regional centres of excellence, with shared research facilities, should be established as part of this effort.

Underlying issues related to equipment donated to Africa should be considered, including:

1. Procurement: clearance problems at the port of entry with consequent costs and delays;
2. Installation: engineers’ expenses difficult to source;
3. Maintenance and repairs: lack of trained personnel, engineers’ expenses;
4. Experimental hardware: lack of specialized instrumentation (e.g. GC/MS) in African universities, as well as a shortage of trained personnel able to use and maintain such equipment;

**TECHNOLOGIES TO PROTECT AND IMPROVE WATER QUALITY**

The Pan Africa Chemistry Network coordinates and supports activities aimed at building capability and capacity in this area. Examples are the commissioning and installation of gas chromatography-mass spectrometry instrumentation at Jomo Kenyatta University of Agriculture and Technology, Kenya, and more recently at Addis Ababa University, Ethiopia, and the provision of analytical training courses for researchers across Africa. The ultimate aim is to develop well-equipped chemical research communities by supporting regional centres of excellence. It is important that these centres are supported, promoted and continuously funded.

**3.0 METHODOLOGY**

**MAP OF AFRICA**

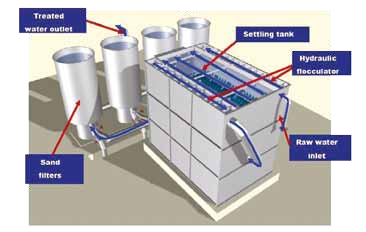


**METHODS TO BE USED ARE**

* **EPA Compact Water Plants utilised in Africa for small and remote communities**

EPA (Estación Potabilizadora de Agua) Compact Water Plants use a conventional treatment system (coagulation, flocculation, sedimentation, rapid filtration and disinfection process) with no need of pumps; instead they use hydraulic flocculation, a settling tank and rapid sand filters. Erection of the plant, training and the necessary intake and distribution works are standardized, achieving a whole product solution. Operation of the plant requires only a low energy input (e.g. 4 hp - EPA 20, delivering 20 m3/hr ), when compared with other conventional solutions or more sophisticated technologies. In addition, operation of the plant is straightforward and can be carried out by one person. Local personnel can easily be trained to operate the plant and take charge of its maintenance.

In the case of four communities served by EPA Compact Water Plants, it was noted that they developed a feeling of “ownership”. They agreed to charge a fixed sum of money per litre of treated water, assuring the funding for proper operation of the plant. Anticipating the needs of remote communities without access to an electricity supply or other fuel source, a new model of the Compact Water Plant has recently been introduced. This new model includes a solar panel which covers all the energy requirements (1 hp), while delivering half the flow rate of the original model (10 m3/hr). Erection of this model is also easier, reducing the overall cost of the plant, and allowing communities to recover their costs more quickly.



EPA General Technical Specifications

(Dimensions: 4 m length, 2 m width, 3.5 m height

* **Water purification using natural plant coagulants (*Moringa oleifera* seeds and *Maerua decumbens* root)**

Sources of water in the water-scarce areas of the Kitui and Mwingi districts of Kenya include seasonal rivers, shallow dug wells on dry river beds, sand dams and wells, and open pans. These water sources have been reported to be turbid and contaminated with microorganisms, especially during the rainy season. The indigenous people of the Kitui district improve the quality of water available to them by using powdered *Moringa oleifera* seed and ground *Maerua decumbens* root to clarify the turbid water. In order to test this method of water purification, seeds of *M. oleifera* and root of *M. decumbens* were washed, oven-dried and then ground and stored in sterile, air-tight glass jars. Turbidity and microbiological analysis were then carried out on test water, before and after treatment with the plant coagulants. The root of *M. decumbens* reduced the turbidity of slightly turbid water by 95% and highly turbid water by 50% but was found to impart colour to the water. The seeds of *M. oleifera* reduced the turbidity of slightly turbid water by 98%, and of highly turbid water by 77% and impacted no colour and odour on the water. In addition, the root of *M. decumbens* and seeds of *M. oleifera* reduced the pathogenic microbial count by 99% and 100%, respectively.

In conclusion, both *M. oleifera* seed and *M. decumbens* taproot extracts have been shown to clarify and disinfect water; however, the former is superior. As such, communities living in arid areas should be encouraged to grow the plant *M. oleifera* both for food and to use the seeds for water purification.

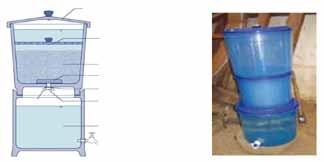


Shallow dug well on a river bed

* **Development of a household water de-fluoridation process for developing countries**

High levels of fluoride in groundwater has been reported parts of in Ethiopia, Malawi, Kenya and Tanzania and can lead to health problems including dental fluorosis, osteosclerosis, thyroid problems, growth retardation and even kidney failure. Most of the methods currently available for the removal of fluoride from drinking water are either too expensive, are technically unfeasible for household use or change the water quality. In this study, the removal of fluoride from water using aluminium hydroxide has been investigated and a household defluoridation unit (HDU) has been designed and tested.

A HDU packed with 0.9 kg of adsorbent with 28.3 cm bed depth resulted in a specific safe water yield of 823.79 L under the optimum operating conditions used in this study. Regeneration of the exhausted media using 1% NaOH and 0.1 M HCl showed that the adsorbent could be reused. The estimated running cost of the unit was 28 USD/m3 of treated water, which can be minimized further. Hence, it is concluded that this proposed method is simple and has superior performance for the treatment of fluoride contaminated water with potential application in both household and community water treatment systems.



**Top lid**

**Removable perforated**

**distribution plate**

**Activated Alumina**

**Micro filter**

**Rubber washer**

**1.5**

**mm diameter orifice**

**for water drip**

**Treated water**

**collecting chamber**

**CONCLUSION**

Water quality would be very beneficial in the development of a future water resource program in the AFRICA. In fact, the origin of iron, manganese and lead needs to be investigated by also considering the hydro-geological characteristics of the sampling sites. Only by identifying the sources of contamination will it be possible to select and implement the most correct and appropriate solution to these quality issues.

**RECOMMENDATION**

1. A strong focus on developing and improving technologies to conserve and reuse water for agriculture is required; including optimizing water use, treatment of contaminated water, recycling water, desalinating water and harvesting water for irrigation.
2. Modern biotechnology should be used to develop crops that are resistant to attack by pests and to environmental stresses, including drought and salinity. Nutritionally enhanced crops also hold tremendous potential to provide significant benefits for human and livestock nutrition, health, welfare, and growth.
3. Higher yields from crops should be sought through enhanced responsiveness to fertilizers and pesticides.
4. Farmer education in the use and storage of plant protection products should be continued.
5. The impact of agriculture on the entire cycle of water use and water governance should be recognized. Water in agriculture is both a source of water pollution (return flows, groundwater contamination and surface water eutrophication and salinization) and is impacted by poor quality water – especially in the use of untreated wastewater in vegetable production and in the impact on farmers’ health through exposure to water-borne pathogens.
6. Scientists should become role models in Africa, communicating with the non-scientific public about the role of science in society, raising the profile of science and attracting into the scientific domain the brightest and best of the next generation.

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