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Water Governance Approach: Analytical Framework for Sustainable Drinking Water Supply in Nakuru Town

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ABSTRACT

Nakuru town is currently facing a governance crisis of its drinking water supply framework. Constitutionally all water users, have a right of access to clean and safe water in adequate amounts, therefore it is important for the town to adopt good practices in its water governance framework for effective, efficient, inclusive and sustainable management of its water supplies using scientific based decision making approach. Data collection and analysis involved statistical, qualitative and quantitative techniques. Water samples were taken to represent all components of the water supply distribution system. Aspects of the area's water use policies, regulatory framework, capacity of institutional and technical instruments, challenges in water service delivery and interests of water users were evaluated. Results show that overall governance of drinking water supply framework is ineffective, inefficient and lacks inclusive governance. Water analysis results show that most of the parameters in groundwater had elevated levels in line with drinking water guideline values set by the (WHO) and Kenya Bureau of Standards (KEBS) compared to river water posing significant risks to human health. The study concludes that Nakuru Town needs to adopt analytical governance approach for its drinking water supply framework for sustainable management, development and research.

KEYWORDS: *Spatial trends, water quality, water governance, analytical framework, Nakuru Town*

INTRODUCTION

GWP (2002) defines water governance as the range of political, social, economic and administrative systems that are in place to regulate the development and management of water resources and provision of water services at different levels of society. The continued water supply deficit, worldwide, has been attributed to water governance crisis. In many documents, the current water crisis, in which almost half of the world's population has no or insufficient access to clean water and sanitation, is referred to as governance crisis (Herman et al., 2016). According to UNDP 2004, water crisis is a largely silent crisis. About 1.1 billion people lack access to improved drinking water supply (WHO, 2011). Water is central to humanity's social and economic existence (Agnew and Woodhouse, 2011). Not having access to safe water therefore, is a form of deprivation that threatens life, destroys opportunity and undermines human dignity (UNDP, 2006). Cognizant of the importance of water, the United Nations General Assembly recognized the human right to water and sanitation. Despite such aspirations, safe water access is still a challenge.

Water governance guides, directs, enables and enhances effective and sustainable water management and provision (Kjellén et al., 2015). Effective water governance becomes more important as water becomes scarcer, it must ensure that all sectors of society have equitable, reliable and sustainable access to water and are using water efficiently (UNDP, 1994). There are significant and serious gaps in developing countries between land, water use policies and governance, between policymaking and its implementation, often due to institutional resistance to change and corruption.

Kenya has an excellent, modern water governance framework. The issues lie in its implementation. Enforcement has been weak, and many of the provisions have not been implemented. Existing policy, legal and institutional frameworks are deficient from the perspective of groundwater management. An overhaul is required to bring them in line with the requirements of frameworks for sound groundwater management (George and Isaac, 2009).

Sustainable water supplies are essential to the growth of regional or local economic hubs, also a part and parcel of good local governance (ISSD, 2013). Across the globe, increased demand and water mismanagement have put stress on water services. As a result, there has been a growing societal recognition of the need to look at sustainable solutions that allow for everyone to have access to clean water. Securing water (quality and quantity) to satisfy the needs of humans and ecosystems is one of the primary issues challenging the 21st century (Amangabara and Ejenma, 2012). Globally, cities face challenges like water scarcity that threatens their efforts to be centers of sustainable development and innovation (Grig, 2016). The first step towards sustained access to safe water services is to draw an understanding of the current situation, by identifying and addressing the gaps in service delivery and the institutional capacity.

Nakuru Town is currently facing a crisis in its water security and governance affecting sustainable social and economic developments as they are largely dependent on water resources. Challenges in water quality are further amplified by a host of current and emerging environmental stressors. The nature and concentration of chemical elements and compounds in a freshwater system are subject to change by various types of natural processes – physical, chemical, hydrological and biological caused by climatic, geographical and geological conditions. The town's current concern is the effect of natural and environmental factors and processes on water chemistry. According to John 1990 and Drever 2000, where water chemistry is controlled by regions geology, elemental characteristics of water can change significantly.

The Towns water utility is managed by Nakuru Water and Sanitation Services Company Ltd (NAWASSCO) which is a corporate entity incorporated in September 2003 under the companies Act CAP 486 of the Laws of Kenya. The Municipal Council of Nakuru is the sole shareholder (Ezekiel and Gilbert, 2015). The present water demand for Nakuru is estimated to be 100, 000 m^3/day, while water supply can currently only provide half of this amount. This shortage, particularly severe in the densely settled, low-income areas of the city, is seriously aggravated by the failure of the water distribution network to expand in line with the increase in population (Onjala, 2002; Sering et al., 2004).

Though highly mineralized, groundwater is the major source of water in the area. Water obtained from groundwater wells have higher levels of fluoride than that obtained from surface source. Some boreholes have a higher fluoride content (of up to 19 mg/l) than the World Health Organization recommended level of 1.5 to 3 mg/l. As a result Nakuru Water Company blend water from boreholes with water from the rivers to reduce fluoride content (Ezekiel and Gilbert, 2015). Quality control is maintained at only one water use point at outlet of the blending plant. Quality control to check fluoride levels at other water use points along the distribution network does not exist hence information on fluoride level is not known. NAWASSCO's water supply network covers about 65% of the municipality (an area of about 110 km^2) (Owuor and Foeken, 2009).

Water for Life report (WHO, 2011) describes the consequences for poor people without adequate access to water: diarrhoeal diseases, worm infections and other infectious diseases spread via contaminated water, and lack of water makes it difficult for families to maintain basic hygiene around the home. Given that inadequate knowledge of the value of water-quality benefits threaten safe and sustainable water resources, sustainable water services are critical to providing the public with clean, safe water and helping ensure the environmental, economic and social sustainability of the communities these utilities serve (EPA, 2014).

Against this backdrop, acknowledging that the complexities of water challenges in Nakuru Town town cannot be met solely by field specific approaches, there is need to develop baseline information that can direct possible analytical governance approach for sustainable safe drinking water supply framework. As an integrated whole, to provide real workable solutions, the effect of the regions natural factors, natural processes and contaminant factors associated with water distribution systems on drinking water quality with particular attention to the health of users will be assessed. The significance of this research is measured in terms of generating important information and lessons learned from the past and present water supply systems as per existing drinking water utility of Nakuru Town. The objectives are;

1. To identify gaps in water governance framework of Nakuru town drinking water supply system.
2. To determine spatial distribution trends of pH, temperature, fluoride and electrical conductivity in drinking water supply of Nakuru Town.
3. To formulate analytical framework that can improve the areas water governance cycle for sustainable management and development of drinking water supply and services.

RESEARCH METHODOLOGY

Study area

Nakuru town located in Nakuru County is the fourth largest and one of the fastest growing metropolitan in Kenya. It is located in the heart of the Great Rift Valley between latitude $0^0$10' and $0^0$20' South and longitude 36^0 0' and $36^0$10' East, at a distance of 160 km north-west of Nairobi. The total area of the municipality is about 300 km^2.

Hydrology and geology

The geology of Nakuru area comprises mainly of volcanic soils and rocks (lava and pyroclastics) of Tertiary – Quaternary age, which has been affected by a series of faulting, and are overlain by recent sediments (Daniel et al., 2009).

The hydrology is controlled mainly by climate, tectonically controlled morphological, volcanic barriers, faults and local water table variations. Dramatic changes have taken place in the hydrology of the area during the Holocene, with undoubted impacts on groundwater quantity and quality though no data is available to assess its magnitude and extent (Daniel et al., 2009).

Water supply

Water supply sources include; River Malewa and Meroronyi, groundwater (boreholes located at four well fields) and River Turasha water supply in Gilgil (Ezekiel, 2014; 2015).

Research design and sampling method

The research utilized literature search, descriptive survey research design and stratified systematic point line sampling technique. An extensive review of drinking water supply governance framework of Nakuru town water service provider, natural factors and potential conditions associated with water distribution systems, their effects on water quality and possible risk to users was undertaken. Ties between water management practices and water quality were explored.

Qualitative semi-structured interviews were conducted with individuals who had considerable knowledge about the current water situation in Nakuru Town and who know the challenges that NAWASSCO is facing in terms of providing water and how the water institutions can adapt to these challenges. This included stakeholders and other water users, staff of the towns drinking water supply company (NAWASSCO) and personal observations. Secondary data were also collected from books, journals, project documents, reports from sectoral offices, and other concerned bureaus in and outside the county.

Water quality sampling

pH, temperature, electrical conductivity and fluoride were selected as indicators to assess water quality status of the areas drinking water supply system. Their choice was based on them being widely used as important indicators to identify inorganic constituents (minerals) of significant risk that occur in drinking water and other uses in water supplies and to note variation or changes in natural waters quickly (WHO, 1993). The parameters were also chosen based on the possibility of tracing their origin in relation to the area's natural and environmental conditions such as geology, climate and geographical variations.

Standard procedures recommended by American public health association (APHA, 1992; 2005) were followed in water sample collection. Selection of sampling points for the basic components of the water supply system was based on WMO 2013 Technical Report on Planning of Water Quality Monitoring Systems. Thirty two (32) sampling points represented groundwater while six (6) sampling points represented river water. The sampling frequency was on monthly basis for groundwater while river water was on weekly basis. A total of 320 groundwater and 240 river water samples were collected continuously for 10 months. The sampling period represented three seasons of the study area that is end of long rain, short rain and dry season. Selection of sampling points was based on the objective of obtaining representative samples which fully reflect the conditions of the water supply system basic components (source of supply, treatment plant facilities, water use points composed of storage reservoirs, tap outlets and water kiosks managed by NAWASSCO) at a specific point and space.

Data analysis

Information gathered through observations, interviews with key informants and discussions by use of structured questionnaires was qualitatively analyzed to draw an understanding of the existing status of the area's drinking water supply governance framework. Laboratory analysis was done for fluorides while onsite analysis was done for pH, temperature and electrical conductivity by use of Jenway electrochemical analyzer. Descriptive statistics was used to quantitatively analyze water quality data whereby minimum, maximum, range and mean values of each measured parameter was used. Range value was used as a measure of spatial variability of each measured parameter among all the sampling points. The values of measured parameters were evaluated against guideline values for drinking water by WHO and KEBS to ascertain their suitability for drinking purposes.

RESULTS AND DISCUSSIONS

Spatial distribution trends of measured water parameters in Nakuru Town drinking water supply system

Spatial variability in river and groundwater quality in Nakuru Town drinking water supply components was assessed by analysis of selected parameters. Analysis results of pH, fluoride, temperature and electrical conductivity are presented (Table 1 and 2).

Water quality properties measured in Nakuru Town drinking water supply from source through treatment facilities to water use points showed a large range of values among sampling points and with time. pH value in groundwater ranged from 5.93 to 10.54 with a mean value of 8.2 while in river water the range was 6.33 to 9.26 with a mean value of 7.80 which was within WHO (2008) and KEBS (2007) recommended guideline values drinking water. Water temperature in groundwater ranged from 20.4^{o}C to 41.4^{o}C. In river water temperatures ranged from 14.23^{o}C to 26.05^{o}C. There are no set standards for temperature limits in drinking water by WHO and KEBS. According to UNICEF 2008, groundwater temperatures with an average value of 27.7°C is generally ambient and good for consumers who prefer cool to warm water and for the specific reason of water quality since **high temperature** negatively impact water quality by enhancing the growth of micro-organisms which may increase taste, odour, colour and corrosion problems. Practically it is also desirable that temperature of river drinking water should not exceed 15^{o}C because the palatability of water is enhanced by its coolness. Observed levels of temperatures in river and groundwater were attributed to the areas local temperature variations, climatological factors, hydrothermal discharges and depths of the boreholes. Fluoride levels in river and groundwater had elevated levels in reference to WHO and KEBS standards for drinking water. Level of fluoride in groundwater ranged from 0.10 mg/l to 14.50 mg/l with a mean value of 7.3 mg/l while in river water the range was from 0.13mg/l to 4.58 mg/l with a mean value of 2.34 mg/l. Level of electrical conductivity in groundwater ranged from 121 µs/cm to 991 µs/cm with a mean value of 556 µs/cm while in river water the range was from 90.00 µs/cm to 280.50 µs/cm with a mean value of 185.25 µs/cm. The results indicated that groundwater's of the area are highly mineralized compared to river water. This was attributed to the area's geological environment, climatic factors, hydrological, topographical variation factors, atmospheric inputs, spatial distribution of the sampling points and water sources, contaminant factors along the supply chain and input from anthropogenic sources.

Oketch, 2012; kanda, 2010; on influence of natural and anthropogenic factors on surface and groundwater quality in the larger Nakuru Basin, conclusively agree with the above. Daniel et al., 2009; Tavassoli and Khaksar, 2002; Naslund and Snell, 2005 concur with the findings based on studies from the wider rift valley region where Nakuru lies.

In reference to environmental management and co-ordination (water quality) regulations/KEBS (2007) and WHO (2008) standards for drinking water, the state at which water reaches the consumer is not good as the investigated parameters which are very important in giving baseline information of any water body exceeded the upper limits of drinking water.

Table 1: Minimum, maximum, mean and range values of groundwater measured parameters

Sampling Site	**Descriptive results**	**Fluoride (mg/l)**	**pH**	**Temperature °C**	**Electrical conductivity (µs/cm)**
At treatment plants and storage reservoirs	Minimum Maximum Mean Range	0.10 9.50 4.80 9.4	5.93 7.18 6.39 1.25	25.5 37.6 31.55 12.1	212.00 980.00 596.00 768.00
At points of consumption	Minimum Maximum Mean Range	0.11 5.74 2.93 5.63	8.30 9.42 8.86 1.12	22.4 30.2 26.3 7.8	121.00 486.00 303.50 365.00
Boreholes at source grouped into four well fields	Minimum Maximum Mean Range	0.23 14.50 7.37 14.27	5.93 10.54 8.24 4.61	20.4 41.4 30.9 21.00	205.00 991.00 598.00 786.00
WHO Guideline value (2008)		Maximum limit 1.5 mg/l	Range: 6.5– 8.5	-	Maximum limit 500 (µs/cm)
KEB Guideline value (2007)		Maximum limit 1.5 mg/l	Range: 6.5– 8.5	-	Maximum limit 400 (µs/cm)

Source: Researcher (June 2014 to March 2015)

Table 2: Minimum, maximum, mean and range values of river water measured parameters

Sampling sites	**Descriptive Results**	**Fluoride (mg/l)**	**pH**	**Temperature °C**	**Electrical conductivity (µs/cm)**
At Treatment plant	Minimum Maximum Mean Range	0.13 2.35 1.24 2.22	6.84 8.95 7.90 2.11	15.75 23.98 19.87 8.23	91.25 175.75 133.25 84.50
At points of consumption	Minimum Maximum Mean Range	0.51 4.58 2.51 4.07	6.44 9.26 7.85 2.82	17.03 24.20 20.61 7.17	121.25 280.50 200.88 159.25
At outlet and inlet points of supply mains	Minimum Maximum Mean Range	0.21 4.08 2.15 3.87	6.33 9.50 7.91 3.17	14.23 26.05 20.14 11.82	90.00 270.00 180.00 180.00

WHO Guideline value (2008)	Maximum limit 1.5 mg/l	Range: 6.5– 8.5	-	Maximum limit 500 (µs/cm)
KEB Guideline value (2007)	Maximum limit 1.5 mg/l	Range: 6.5– 8.5	-	Maximum limit 400 (µs/cm)

Source: Researcher (June 2014 to March 2015)

Structured survey questionnaire and Qualitative semi-structured interviews

The analysis of information from interviews and questionnaires contributed to a better understanding of the current drinking water supply situation in Nakuru Town. Understanding water source quality and changes throughout the system is important as water quality varies throughout the system. Potential hazards and their level of risk can also be identified and documented based on their likelihood of and severity of the consequences.

Water supply, challenges and constraints

In Nakuru Town, the main water provider for public drinking water supply is Nakuru Water and Sanitation Services Company (NAWASSCO). Their responsibilities include; water supply provision, management of water services, maintenance, operation of water production and distribution systems (Ezekiel, 2015). Most of the low-income neighborhoods are not connected to the water supply system. The existing sewerage system covers only the central business district and some parts of the industrial area. Most of the days of the week, there is water rationing so the population lacks access to clean and enough water. Estimated water leakage is about 19,000 cubic metres per day and this is attributed to illegal connections, the high number of unmetered connections, defective meters and leakage of long service lines. Water supply and access to clean water is not sustainable. For instance, at present the water provider (NAWASSCO) does not make much profit from its operations but can only manage its operation and maintenance. The water supply and distribution piping system also lacks a method of tracking the percentage of water losses per system input volume. Vandalism, broken pipes, leaks and illegal connections to the system was noted along the supply chain. Similar observations were made by Sering et al., 2003; 2004 on their appraisal report of Rift Valley Water Supply and Sanitation Project.

Water governance

Results of the study indicate existence of crisis in the areas water governance framework that threatens water security and the regions sustainable development. The study identified the following gaps in the areas drinking water supply governance framework; administrative conflict in the town's drinking water provider and the municipality, ineffective institutional and technical capacity to operate, maintain, manage, bill and collect revenues from the water supply facilities, weak enforcement of drinking water regulations framework and policies, lack of capacity of the water provider to deliver efficient water services, lack of accountability, lack of co-operation and knowledge sharing between water users and institutions. Similar observations were reported by Onjala, 2002 in related studies in Nakuru area and the country at large where he confirmed existence of poor governance in management of water services. Organization for Economic co-operation and Development (OECD) countries report on water governance at a multi level approach by Herman et al., 2016: 2013); United Nations Development Programme (UNDP, 2004), agree that water crisis is mainly a crisis of governance but not essentially as a result of absolute water scarcity.

CONCLUSIONS

This study therefore concludes that Nakuru Town drinking water supply system is facing a water scarcity and governance crisis that is affecting sustainable management of drinking water supply and development. Water analysis data reveals that river and groundwater of the area can be described as highly mineralized and of slightly acidic to neutral to alkaline type. The study also established that natural factors, natural processes and contaminant factors along the water supply chain with input from anthropogenic factors are major and important elements controlling the areas quality of drinking water supply systems.

Considering the towns existing water governance gaps and drinking water supply problems, it is important to formulate a drinking water supply framework defined by best practices of water governance to bridge the current and future water challenges. To ensure its effectiveness, efficiency and inclusivity, interests of the existing water supply system, water users, aspects of institutional and legal instruments which include responsible authorities and drinking water regulations should be integrated. For the way forward, necessary investments, research and analysis to inform institutional capacity building and policy development for effective water resources management that create diffuse local management capacity in the town should be emphasized.

RECOMMENDATION

For Nakuru Town, analytical framework characterized by good practices of water governance should be adopted to ensure sustainable drinking water supply and services.

REFERENCES

i. **Agnew, C.** and **Woodhouse, P.,** (2011). Water Resources and Development. London and New York: Routledge.

ii. Amangabara, G.T. and Ejenma, E.E. ”Groundwater Quality Assessment of Yenagoa and Environs Bayelsa State, Nigeria between 2010 and 2011”, Resources and Environment, vol. 2, no. 2, pp. 20-29, 2012.

iii. Drever, J.I., 2000. The Geochemistry of Natural Waters. Prentice-Hall, Inc., Englewood Cliffs, NJ, 388p.

iv. EPA, (2014). Moving towards sustainability. Retrieved from https://www.epa.gov/sustainable-water-infrastructure.

v. APHA, (1992). Standard Methods of Examination of Water and Waste Water, 18 th edition, USA.

vi. Ezekiel, A. and Gilbert , M. (2014; 2015). Personal communication. NAWASSCO.

vii. George, M. Ogendi and Isaac M. Ong'oa, *Water Policy, Accessibility and Water Ethics in Kenya*, 7 Santa Clara J. Int'l L. 177 (2009). Available at: ttp://digitalcommons.law.scu.edu/scujil/vol7/iss1/3

viii. John, D. Hem. (1990). Study and Interpretation of the Chemical Characteristics of Natural Water. Third Edition. Department of The Interior William P. Clark, Secretary U.S. Geological Survey Dallas L. Peck, Director.

ix. Naslund, J. and Snell, I. (2005). GIS Mapping of fluoride contaminated groundwater

x. in Nakuru and Baringo districts of Kenya. MSc Thesis, Lulea University of Technology, Sweden.

xi. Kjellén, M., Tropp, H. & Jiménez, A. (2015). *Water governance in perspective – Water Governance Facility 10 years 2005-2015.* Stockholm, SIWI.

xii. KEBS, (2007). Drinking Water Specification, The Requirement for Drinking Water 3rd Edition Nairobi Kenya.

xiii. UNICEF, 2008. UNICEF Handbook on Water Quality. United Nations Children's Fund (UNICEF), New York, USA., Pages: 179.

xiv. UNDP, Human Development Report: Beyond scarcity: Power, Poverty and the Global Water Crisis. 2006. UNDP.

xv. GWP (Global Water Partnership), (2002). Dialogue on Effective Water Governance. Stockholm, Sweden.

xvi. ISSD (International Institute for sustained development), (2013).

xvii. Grigg N.S, (2010). Governance and management for sustainable water systems. IWA Publishing, London.

xviii. OECD. ''Water Governance Initiative: Terms of Reference'', OECD Regional Development

xix. Working Papers, OECD Publishing. (2013). http://www.oecd.org/gov/regional-policy/Terms-ofReference%20-OECD-WGI.pdf

xx. Herman Havekes, Maarten Hofstra, Andrea van der Kerk, Bart Teeuwen, Robert van Cleef and Kevin Oosterloo (2016). Building blocks for good water governance. Water governance centre (WGC). https://www.uvw.nl/wp-content/uploads/2017/11/Building-blocks-for-good-water-governance-2016.pdf

xxi. Onjala, J. (2002). Good Intentions, Structural Pitfalls: early Lessons from Urban Water

xxii. Commercialisation Attempts in Kenya. CDR Working Paper 02.02, Centre for Development Research, Copenhagen, January.

xxiii. Owuor S.O. and Foeken, D. (2009). Water reforms and interventions in Urban Kenya. institutional set-up, emerging impact and challenges. ASC Working Paper 83/2009. Leiden: African Studies Centre. The Netherlands

xxiv. Sering, J., Lamin, B., Daniel, L., and Idrissa S., (2003;2004). Rift Valley Water Supply and Sanitation Project Appraisal Report. Republic of Kenya.

xxv. Tavassoli A. and Khaksar K. (2002). Effects of geological formations on quality of quaternary aquifers. XII Congresso Brasilero de Aguas Subtereneas. Research center. Tehran, Iran.

xxvi. UNDP, (1994). Human Development Report 1994: New Dimensions of Human Security. UNDP, New York.

xxvii. UNDP (2004). Water Governance for poverty reduction, key issues UNDP Response to Millenium Development Goal, United Nation Development Programme Bareau for Development policy 304 ES 45th Sreet New York.

xxviii. WHO, (World Health Organization, 3rd Edition) (2008). Guideline for Drinking Water Quality Geneva.

xxix. WHO (World Health Organization), (1993). Guidelines for drinking water quality; Vol. 1. Recommendations (2nd Ed.), WHO, Geneva.

xxx. WHO, (World Health Organization, 4th Edition) (2011). Guidelines for Drinking-Water Quality, WHO Press, Geneva, Switzerland.

xxxi. WMO (World Meteorological Organization), 2013. Planning of Water Quality Monitoring System Technical Report: WMO-No. 1113. Geneva, Switzerland.

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