Moshi Urban Water Supply and Sanitation Authority

Case Study on Water Safety Plans Implementation, Benefits and Challenges

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List of Abbreviation

CI	Cast Iron
DCI	Ductile Iron
ISO	International Standards Organization
IWA	International water Association
KCMC	Kilimanjaro Christian Medical Centre
MD	Managing Director
MUWSA	Moshi Urban Water Supply and Sanitation Authority
NRW	Non – Revenue Water
PE	Polyethylene
QMS	Quality Management System
TBS	Tanzania Bureau of Standards
TZS	Tanzanian Standards
uPVC	Unplasticized Polyvinyl Chloride
WHO	World Health Organization
WOP	Water Operators Partnership
WSP	Water Safety Plan

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Biographies

Speaker 1 : Eng. Issa Y. Osena.
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Company : Moshi Urban Water Supply and Sewerage Authority
Country: Tanzania

Eng. Issa Osena, is a registered Professional Civil Engineer, with specialization in Water Resources Engineering. He holds BSc. and MSc. engineering degrees from University of Dar es Salaam and MBA degree from East and Southern Africa Management Institute (ESAMI). He is presently working with Moshi Urban Water Supply and Sewerage Authority, Moshi, Tanzania, in the position of Technical Manager, where he is principally responsible with implementation of all measures that ensure adequate and properly functioning Water Supply and Sewerage collection /disposal Systems in Moshi Municipality. Having worked in the Water and Sanitation sector for over 20 years, his experience includes Rural and Urban Water Supply Systems Design, Construction, Operation and Maintanance; Management of Water Supply and Sewerage Infrastructural Development Projects; and benchmarking contacts with leading african water and sanitation utilities eg. Umgeni Water, of Pietermaritzburg, South Africa and NAM Water, of Windhoek Namibia. He has attended various national and international water related trainings and conferences, and is a member of the International Water Association, *IWA.*

Speaker 2 : Eng. Patrick Kibasa.
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Eng. Kibasa graduated from Dar es Salaam University with a major in Civil Engineering specialized in water resources engineering. He holds MSc. Water Recourses engineering from Dar Es Salaam University. He is registered professional Civil Engineer and a member of Institution of Engineers Tanzania.

Eng. Kibasa is currently operations and maintenance engineer at Moshi Urban Water Supply and Sanitation Authority [MUWSA]. In this capacity he is responsible for production and distribution of portable water at Moshi Municipal. He is presently a team leader of MUWSA's WSP team which is responsible for developing, implementing and maintaining the WSP. Prior to

joining the organization he was Technical Manager at Kiliwater Company Limited, an autonomous organization responsible for provision of clean, safe and portable piped water at Rombo district and parts of Moshi district in Kilimanjaro region, Tanzania. While there, he was responsible for water production, distribution and coordination of all technical matters of the company. He has an extensive experience in Urban and Rural water supply and sanitation for about 10 years in Tanzania, a wide experience in planning, designing and supervision of water supply and sanitation projects and a broad knowledge of maintenance and repair works.

Abstract

Moshi Urban Water Supply and Sanitation Authority is one of autonomous but government owned utilities responsible for provision of clean and safe water services and collection and disposal of waste water in Moshi Municipality recently the Authority has embarked on formulation and implementation of Water safety plan as one of its service sustainability and improvement measures.

Water Safety Plans (WSPs) are effective means of consistently ensuring the safety of drinking-water supply through the use of a comprehensive management approach that encompasses systemic identification of risks and implementation of control measures at all steps in water supply system from catchments to consumers.

With the Support from International Water Association (IWA) and Water Operators Partnership (WOP), the three Water Utilities of Nairobi City Water and Sewerage Company (Kenya), Mombasa Water and sanitation Company Limited (Kenya) and Moshi Water Supply and Sewerage Authority(Tanzania) are jointly formulating WSPs but tailored for each utility. Each utility has formed a team which is undertaking the tasks of establishing and documenting a WSP specific for their utility. Having started in July 2011, the teams have managed to develop WSPs in their utilities; presently, the teams are fine tuning their documents.

WSPs are now being adopted worldwide as a better approach to protecting water quality and ensuring public health, compared to traditional approach of water quality and safety management which rely on the testing of drinking water either as it leaves the treatment works or at selected points within the distribution system (end-product testing). With WSP, which is preventive based; reactive and curative responses to water quality hazards, which are often characterized with results which are too little and situations whereby it is too late for preventive action, are avoided.

On the other hand, the major challenge experienced is communication to staff involved in WSP implementation that the WSP is not additional work, but is rather a new way of planning and undertaking current work. There is a common perception that WSPs are developed alongside existing managerial and operational tasks and this can often lead to WSPs being viewed as a one-off project. This view can lead to the WSP not being seen as a mainstream activity within a utility's operation and can create unrest or amongst staff that see it only as additional work.

MUWSA background

Moshi Urban Water Supply and Sanitation Authority (MUWSA), is a fully autonomous but government owned organization responsible for ***provision of clean and safe water; collection and disposal of wastewater*** to the population of Moshi, the town of mount Kilimanjaro, and some parts of Moshi Rural and Hai Districts.

MUWSA was first established as one of three semi autonomous commercial oriented Water Departments (together with Tanga and Arusha) in 1994, as Ministry of Water's pilot programme towards ensuring sustainability of water and sanitation services in urban centres. With successful operation and service provision, in July 1998 the Government through Ministry responsible with Water declared a total of 8 regional Water Departments including Moshi as fully autonomous entities . These 8 Water and Sewerage Authorities were Moshi, Tanga, Arusha, Morogoro, Mbeya, Mwanza, Tabora, and Dodoma.

Presently MUWSA is one of the 19 Autonomous Water Supply and Sewerage utilities in category A, which means meeting all operational expenses plus minor investments. MUWSA operates according to the Water Supply and Sanitation Act No 12 of 2009, the Memorandum of Understanding and Guideline between MUWSA and MoWI; and the Performance Agreement between MUWSA and EWURA. MUWSA is governed by the Board of Directors which is responsible for carrying out and managing the functions, business and affairs of the Authority. It is headed by the Managing Director, with 3 Departmental Managers and 12 Sections and Support Units. At present, the Authority has a total of 149 permanent employees.

MUWSA supplies its customers with water which meets both Tanzania and WHO Standards for drinking water, and has been certified by the Tanzania Bureau of Standards (TBS) – certificate no. TZS 789: 2003, as from February 2007.

After being certified by the Tanzania Bureau of Standards for provision of high quality water, MUWSA has also given its best endeavors to establish and optimize a modern, systematic and professional quality management system that complied with international standards so as to provide all its services at the highest quality.

In this regard, MUWSA has been certified by ISO as an organization which meets ISO 9001:2008 quality management system requirements since December 2011.

1.0 Introduction

1.1 Moshi Town

Moshi Municipality, with an area of 58 km^2, lies approximately 3º18'S of the Equator and 38º 20'E of Greenwich Meridian, on the Southern slopes of Mt. Kilimanjaro, the highest roof of Africa. With a total population of about 210,000 people projected from 2002 population Census, Moshi Municipality is an administrative and commercial centre of Kilimanjaro Region. The town is located in the Northeast Tanzania, within a few hours drive to the numerous tourists attractions such as Manyara, Ngorongoro,Tarangire and Kilimanjaro National Parks; Ngurdoto, Momela and Mkomazi Games Reserves and the climbing of Mount Kilimanjaro.

Moshi Municipality has a number of Social-Economic activities, including numerous trainings institutions, for example the famous Police College and 3 University level Colleges, a National Medical Referral Centre, Coffee and Horticulture plantations, and many other Commercial and Entrepreneurial undertakings to which a supply of safe and clean water and the provision of sewerage services is of paramount importance.

1.2 Water Supply and Sewerage Infrastructure

1.2.1 Water Supply System

MUWSA water supply originates from 5 sources, which are 3 springs and 2 boreholes with a total average production of 26,322 m^3 per day, as shown in table No. 1 below. The supply network consists of trunk main and distribution networks made of Steel, DCI, CI, uPVC and PE materials ranging from diameter of 50 mm-500 mm. The total length is about 22 km for the trunk mains, 420 km for distribution lines and 650 km for consumer connections. The total storage capacity is about 8,885 m^3 comprising of reinforced concrete ground tanks. Currently, the distribution network covers 98% of the total service area, whereby 95% of Municipal population is served. As at 30th June, 2012 MUWSA had a total of 19,856 water consumer connections.

Table No 1. Production of water from each source as per June 2012

Type of source	SPRINGS			BOREHOLES		Total Average Production (m^3/day)
Source	Nsere Spring	Shiri Spring	Chekereni Spring	Mawenzi Borehole	KCMC Borehole	
Average Production (m^3/day)	7,553	13,314	1,228	3,470	757	26,322

1.2.2 Sewerage System

MUWSA is running a ***Conventional system*** of collecting, treating and disposing wastewater generated from domestic, commercial, institutional and industrial centres within Moshi Municipality. The service coverage is 14% of Moshi Municipal area, and the population served by this network is 27% of the Municipal population. The remaining population (73%) uses *on-site sanitation*, namely *pit latrines* and *septic tank* systems.

The sewer network has a total length of 51.6 km, with pipes made of uPVC, Asbestos and Concrete. Currently 2,293 customers are connected to this network.

Sewage treatment is done through ***Waste Stabilization Ponds*****,** comprising of *one Anaerobic*, *two Facultative* and *six Maturation* ponds with a total volume of 143,664 m^3.The design capacity is 4,500 m^3 of sewage per day, however the ponds have been receiving only an average of 3,800 m^3 of sewage per day.

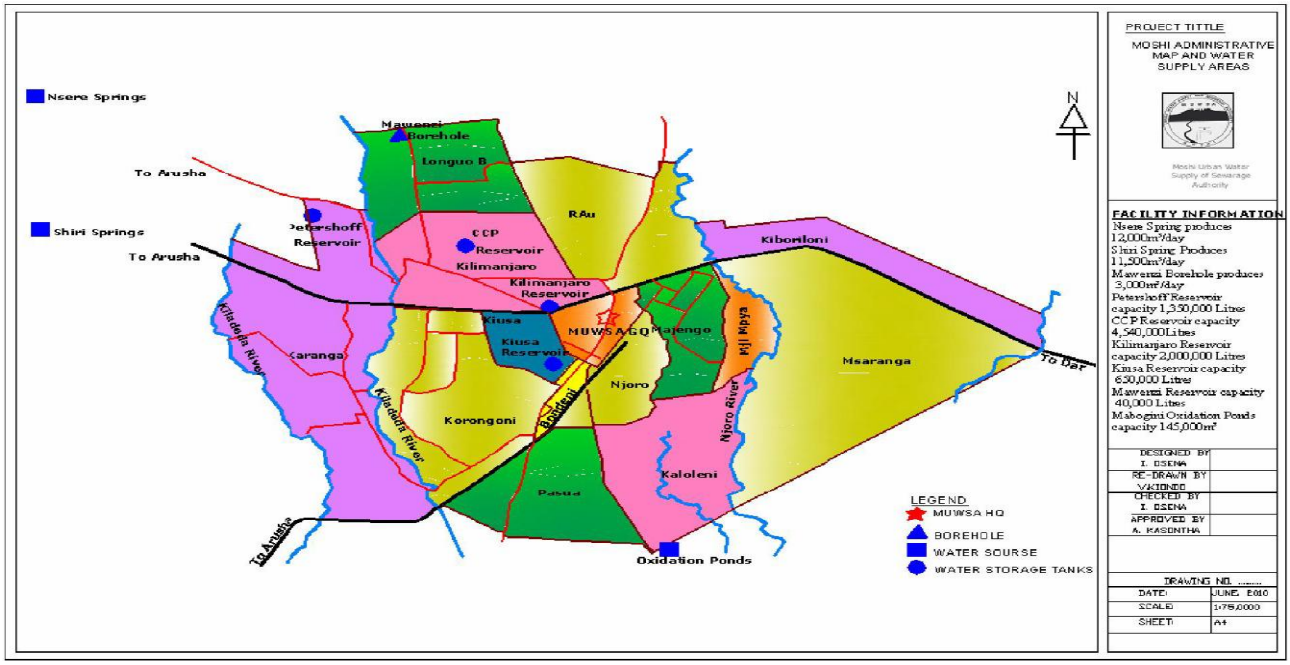

Figure 1: MUWSA Water and Sewerage Facilities Map

2.0 Overview of Water Quality

The quality of water abstracted from three spring sources is excellent; disinfection with Calcium Hypochlorite (65% Chlorine) is the only unit operation done at spring sources. However, in order to safe guard the health of MUWSA consumers' chlorination is carried out again at storage tanks so as to maintain the level of residual chlorine recommended by WHO. On the other hand water produced from boreholes is pumped directly to the distribution network. Table 1 below summarizes the basic parameters for water quality abstracted at water sources and distributed for the past six month.

Despite the fact that most of parameters meet WHO recommended limits, MUWSA has decided to adopt WSP that is central in ensuring safe drinking water now and in the future. WSP entails understanding the risks that allow MUWSA to implement effective controls that safeguard water quality for the entire supply chain i.e. from catchment to consumer's taps. This proactive approach to managing risks means that MUWSA can anticipate problems and protect public health.

Table No 2. Summary of Water Quality from January, 2012 to June, 2012.

Parameters	Water Sources		Storage Tanks	Selected Points in Distribution Network	WHO Recommended Limits
	Springs	Boreholes			
Physical					
pH	6.96	7.2	7.12	7.03	**6.5-8.5**
Temperature (ºC)	22.68	23.33	24.18	24.33	**-**
Conductivity (µS/cm)	95.81	63.66	97.32	95.63	**-**
Total Dissolved Solids(mg/l)	45.74	29.78	47.57	44.01	**1000**
Turbidity (NTU)	0.468	0.458	0.405	0.424	**15**
Chemical					
Chlorine Residual (mg/l)	NIL	NIL	0.278	0.229	**0.2-0.5**
Iron (mg/l)	0.046	0.028	0.029	0.027	**0.3**
Manganese (mg/l)	0.053	0.062	0.043	0.044	**0.5**
Sulphide (mg/l)	0.035	0.033	0.055	0.031	**0.5**
Fluoride (mg/l)	0.241	0.124	0.163	0.166	**1.5**
Phosphate (mg/l)	3.331	2.092	2.648	2.766	**6**
Ammonia (mg/l)	0.087	0.076	0.083	0.074	**0.5**
Nitrate (mg/l)	7.17	5.94	4.75	7.69	**30**
Microbial					
E. Coli (0cfu/ml)	0	0	0	0	**0cfu/100ml**

Figure 2: Shiri spring

Figure 3: Disinfection facilities at Spring Sources and Reservoirs

3.0 WSP Approach

Water safety plans (WSPs) are a form of water quality assurance through a multi-barrier concept **[1].** The multiple barrier principle implies that actions are required at all stages in the process of producing and distributing water in order to protect water quality. This includes source protection, treatment (when applied) through several different stages, prevention of contamination during distribution (piped or non-piped) and maintenance within households. There are indicators used as primarily means of verification of the WSP in meeting water quality objectives rather than as a routine tool for monitoring water quality **[1].** Moreover, WSPs provides an organized and structured system to minimize the chance of failure through oversight or management lapse. The process provides consistency with which safe water is supplied and provides contingency plans to respond to system failures or unforeseeable hazardous events. Water safety plans can be developed generically for small supplies rather than for individual supplies.

The experience with WSPs to date has primarily been within utility supplies; particularly those in developed countries. A variety of experiences have been documented **[2, 3, 4, and 5]**. This paper presents experience of Moshi Urban Water Supply Authority, The first Tanzanian Water Supply Utility to develop and implement WSP.

4.0 Developing WSPs

WSP comprises, as a minimum, the three essential actions that are the responsibility of the drinking-water supplier in order to ensure that drinking-water is safe **[6].** These actions are:

- System assessment;
- Operational monitoring; and
- Management plans, documentation and communication.

In developing a Water Safety Plan these can be broken down into a series of steps as outlined in figure 1. The major objectives of these steps is to ensure good drinking water supply practice i.e. to minimize contamination of water sources, to reduce or remove contamination through treatment processes and to prevent contamination during storage, distribution and handling of drinking-water.

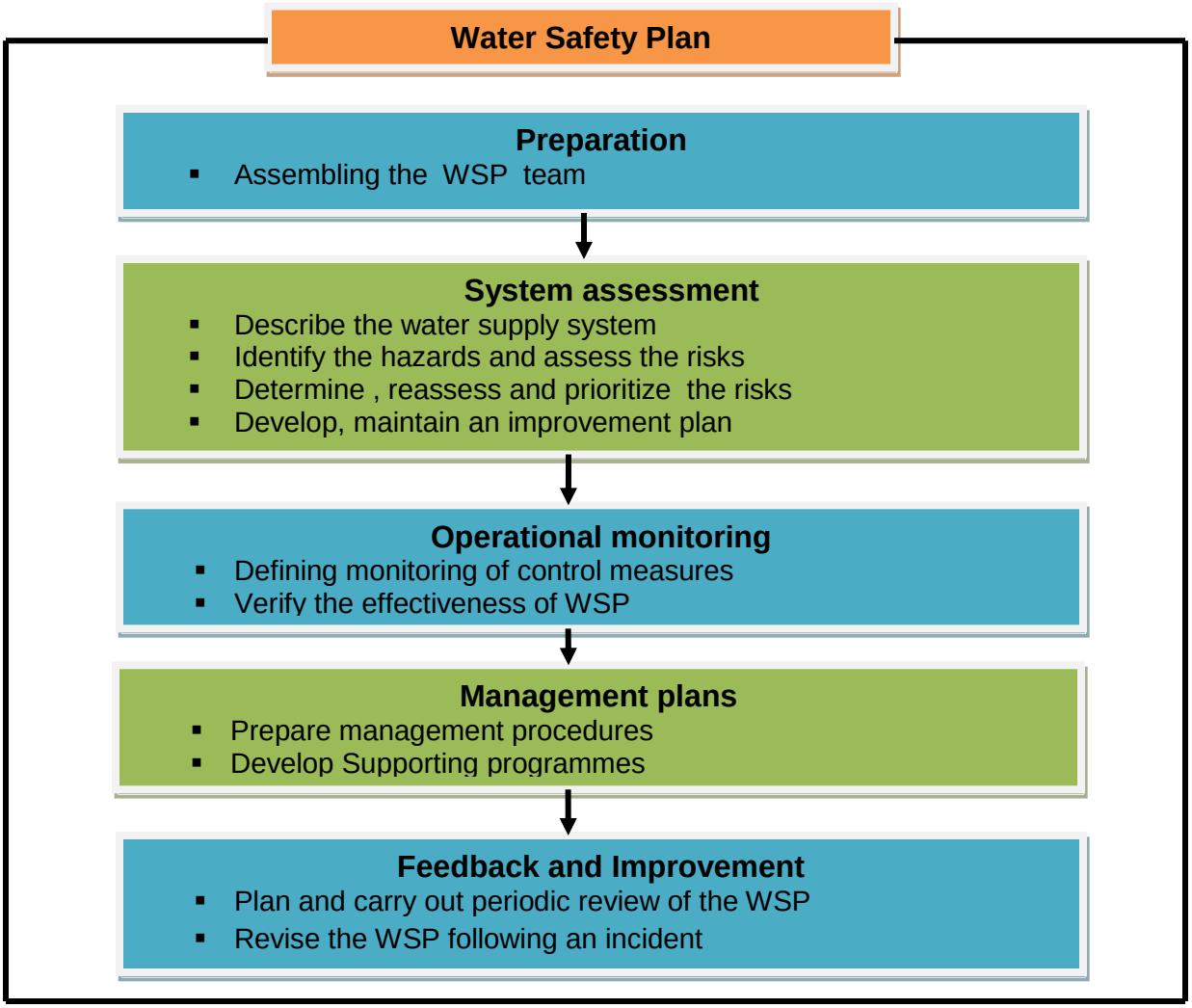

Figure 4: Overview of the key steps in the development of water safety plans

5.0 Development and Implementation of MUWSA WSP

In recognition of the role of management commitment in implementation of WSP, presentation was made to members of management on the benefits of WSP. This process was vital for obtaining support for changes in working practices and to actively promote water safety as a goal of the organization. After having a clear and reasonable argument about why the adoption of a WSP is important and advantageous to MUWSA; WSP was developed following steps outlined in figure 1.

5.1 Preparations

The first step was to assemble a team which is among the prerequisites for development and implementation of WSP. A multidisciplinary team of employees with a thorough understanding of MUWSA drinking water system has been appointed and issued letters of appointment and terms of references by MD. The team constituted technical and non technical staff from the entire supply chain. The team was initially trained by one of WOP partner (Nairobi City Water and Sewerage Company) in Moshi and further training was done by NETWAS Training International with support from IWA. Apart from that some members of the team had an opportunity to attend Technical site visit to other WOP partners i.e. Nairobi and Mombasa cities spearheaded by IWA.

5.2 System Assessment

Description and documented of water supply system is crucial for understanding of the system including the range and magnitude of hazards that may occor and the ability of existing processes and infrastructure to manage actual/potential risks. During this process, various factors for each step in the water supply system were considered (see Table 2). Maps and several information's of the system from long serving technicians were used. Finally the description of the intended use of water was also included and flow diagram of the water supply system was constructed so as to enable hazards to be identified clearly for each component of the system.

Table No 3: Factors Considered during Documentation and Description of the System

Source Water and Catchment	Treatment	Distribution System
Capacity of the source in relation to demand	Process applied	Number of service reservoirs
Protection measures applied	Number of individual units	Volume of these reservoirs
Development in the catchment that affect quality	Age of plant	Age of reservoirs
Known water quality problems	Known design faults	Known design faults
		Area/s of distribution and population served
		Known operational problems

Source: [7]

After constructing a flow diagram for the entire supply chain, potential hazards for the catchments, treatment, distribution network and consumer premises that can affect the safety of drinking water were identified. Furthermore, for each hazard identified, a risk prioritization was then established by means of a calculated risk factor, which was obtained by multiplying the likelihood of its occurrence (ranging from unlikely to almost certain) and the severity of the consequences (ranging from insignificant to catastrophic).

For Control measures which were previous but have been found to be inadequate improvement plans have been drawn up. Each improvement plan has an owner to take responsibility for implementation and an implementation date target. On the other hand, the budget for each improvement plan has been established and incorporated in five years strategic plan of MUWSA and has already been approved by board of directors.

5.3 Operational Monitoring

Monitoring of control measures is essential for assessment of the performance of control measures at appropriate time intervals, so as to ensure the control measures applied at a point in the system are achieving their objectives. Matrices of what has to be monitored, how, where, when and who will do the monitoring have been established from catchment level to consumers taps.

In addition to operational monitoring of the performance of the individual components of a drinking-water system, verification is necessary for reassurance that the system as a whole is operating safely. Presently MUWSA is doing water quality tests i.e. physical, chemical and microbial tests on weekly basis for the entire supply chain. Moreover, MUWSA performs audit (both internal and external audit) so as to ensure all components of water supply system perform as per intended targets. MUWSA has recently received its ISO 9001: 2008 Quality Management System Certificate. Rigorous internal and external auditing have been undertaken prior to certification; and during these audits, the operations records of all treatment processes and distribution system maintenance was reviewed to assess whether they reflect the requirements for each component of the system and documentation for the system which is also an important aspect of WSP. The plan to invite WOP partners is underway for auditing and identification of areas for further improvement. On other hand, as customers' satisfaction is essential for verification of WSP; currently MUWSA performs customers' satisfaction survey semi-annually.

5.4 Management plans

WSP management implies definition of actions to be taken in response to variations that occur during normal operational conditions; of actions to be taken in specific "incident" situations where a loss of control of the system may occur; and of procedures to be followed in unforeseen and emergency situations **[6]**. In view of the fact that MUWSA is ISO 9001: 2008 QMS Certified, all management procedures and work instructions are already in place. Procedures and work instructions which ensure quality of water is not compromised have been adopted and regularly audited and reviewed.

On other hand, there are also many actions that are important in ensuring drinking water safety but do not directly affect drinking water quality. These are consequently not control measures but are referred to as supporting programmes. MUWSA has established a number of supporting progrmmes so as to ensure its WSP control measures are effectively. Table 3 below outlines some supporting programmes in place and their purposes.

Table 4. Established WSP Supporting Programmes

S/No	Supporting Programme	Purpose
1	Preventive Maintenance	To ensures malfunction of important processes are minimized and assets are in good working order
2	Record Keeping	To ensures WSP issues are easily followed
3	Staff Training	To ensure organization personnel understand water safety and the influence of their actions.
4	Control access of people into water sources, treatment plants, reservoirs and implementation of security measure	To prevent transfer of hazards from people when they do enter water sources, treatment plants, reservoirs
5	NRW programmes	To minimize contamination
6	Equipment Calibration	To ensure Water quality is reliable to acceptable accuracy
7	Established research unit	To conduct researches on drinking water hazards, risks and other organization issues

5.5 12 Months Achievements.

WSP implementation has substantially and positively changed the mind-set of operational staff. Water quality related issues are now taken on board during operations and maintenance of components of system because of on the going awareness creation, clear procedures and working instructions in place. Apart from that, supporting staff and the community living in the catchment area are now actively involved in ensuring the quality of water supplied is not compromised. Moreover, with WSP MUWSA has managed to establish a series of monthly reports from which it is possible to have prior understandings of problems and difficulties for an efficient system management.

5.6 Challenges

Although MUWSA has managed to implement WSP, a number of challenges were encountered during development and implementation. Initially most of staff had a common perception that WSP is an additional work, but with training to members of management, WSP has been cascaded down to all staff and positively received together with this, other challenges are inadequacy of laboratory equipment, such that pesticides and heavy metals can not be verified at MUWSA's laboratory. Consequntly samples have to be sent to Tanzania Tropical Pesticides

Research Institute and other laboratories for further verification. Another major setback is lack of funds for further training and implementation of improvement plans for control measures which are not adequate.

5.7 Conclusion

Having developed and implemented WSP in 12 months, WSP is found to be useful to MUWSA. In this short stint MUWSA is now benefiting from change in attitude of staff and culture towards water quality and contamination risk. Systematic workmanship in all procedures has also increased proficiency of work through established and documented procedures and work instructions. Moreover preliminary results indicate that the WSP approach is cost effective.

6.0 References

[1] WHO, Water Safety Plans – Managing drinking-water quality from catchment to consumer, World Health Organization, Geneva, 2005.

[2] Davison, A., Howard, G., Stevens, M., Callan, P., Fewtrell, L., Deere, D. & Bartram, J. 2005 Water Safety Plans: Managing Drinking-water Quality from Catchment to Consumer. WHO/SDE/WSH/05.06. World Health Organization, Geneva, Switzerland.

[3] Davison, A., Deere, D., Stevens, M., Howard, G. & Bartram, J. 2006 Water Safety Plan Manual. World Health Organization, Geneva, Switzerland.

[4] Deere, D., Stevens, M., Davison, A., Helm, G. & Dufour, A. 2001 Management strategies. In Water Quality: Guidelines, Standards and Health. Assessment of Risk and Risk for Water-related Infectious Disease (ed. L. Fewtrell & J. Bartram), IWA Publishing, London, pp. 257–288. Quality management in water supply systems. Wat. Sci. Tech. 53(4–5), 483–492.

[5] Yokoi, H., Embutsu, I., Yoda, M. & Waseda, K. 2006 Study on the introduction of hazard analysis critical control point (HACCP) of the water quality management in water supply systems. Wat. Sci. Tech. 53(4–5), 483–492.

[6] WHO Guidelines for drinking – water quality, 3rd edition. Geneva, World Health Organization, 2008.

[7] Sam Godfrey and Guy Howard, Water Safety Plans (WSP) for Urban Piped Water Supplies In Developing Countries, Water, Engineering and Development Centre, Loughborough University, Leicestershire, United Kingdom, 2004.