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Charnley AK (1992). Mechanisms of fungal pathogenesis in insects with particular reference to locusts. In: Lomer CJ, Prior C (eds) *Biological Controls of Locusts and Grasshoppers: Proceedings of an international workshop held at Cotonou, Benin.* Oxford: CAB International, pp 181-190.

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# Experimental determination of layers films thicknesses

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The determination of particle induced x-ray emission (PIXE) cross sections and the concentration of elements in a material require the knowledge of the target sample thickness. In this aim, measurements of the thickness by three different methods have been performed. These are absorption of X-rays by a <sup>55</sup>Fe source, transmission of alpha particles by a <sup>241</sup>Am source and Rutherford backscattering of alpha particles produced by Van de Graff Accelerator with the use of the RUMP simulation code. The results give a thickness with uncertainties ranging from 1 to 8% according to the experimental technique used. The comparison between these methods gives an advantage for the X-rays absorption for its simplicity and accuracy, when backscattering spectrometry is preferred for thin target on backing or as a complementary technique for PIXE analysis.

**Key words:** Thickness, particle induced x-ray emission (PIXE), Rutherford backscattered (RBS), cross section, rump.

## INTRODUCTION

The technique of samples analysis by charged particles induced x-ray emission (PIXE), requires the knowledge of the targets thicknesses in order to determine the concentrations of the elements present in the sample and for the matrix effect correction. The same applies for the calculation of the ionization cross section:

$$d\sigma/d\Omega = dN/AdxI$$

where dN, Adx and I represent respectively the number of emitted X-rays, of target atoms and the intensity of the beam of incident particles.

In the aim of selecting a technique allowing the thickness determination of a target with the best possible precision, several methods of measurement have been undertaken and these are:

- (a) Transmission of alpha particles given by a radioactive source or produced by an accelerator.
- (b) Rutherford backscattered (RBS) of alpha particles

produced by an accelerator.

- (c) The attenuation of X-rays resulting from an iron source (<sup>55</sup>Fe).

Some of these methods are usually used in PIXE measurements (Johansson and Campbell, 1970; Tran et al., 2002; Ekinici and Valles, 2001). The various measurements were carried out at the Nuclear Research Centre of Algiers (CRNA) of the Commission of Atomic Energy (COMENA), in the division of the nuclear techniques. Self-supported targets whose thicknesses were measured by piezoelectric quartz during the evaporation process, commercial targets with thickness is given by the manufacturer and finally targets deposited on a substrate of silicon and of unknown thickness.

## Preparation of the targets

The preparation (Ourabah and Amokrane, 2006) of the

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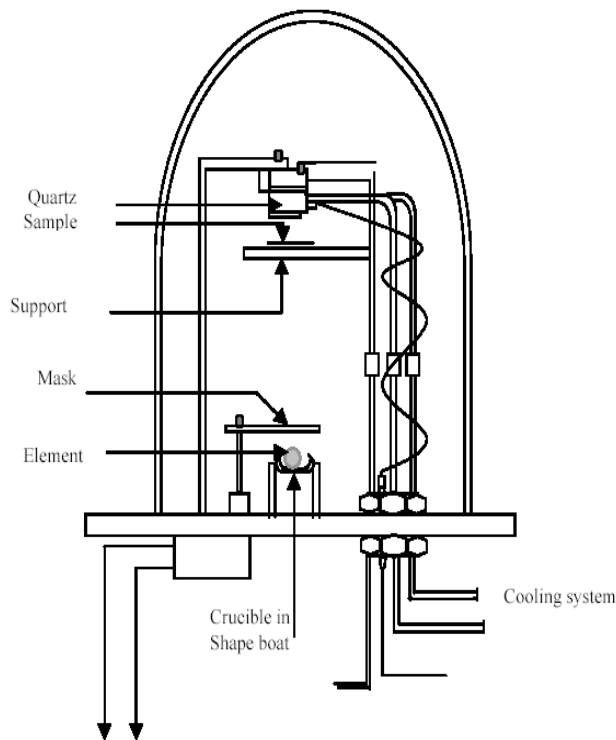


Figure 1. Evaporator with piezoelectric quartz.

targets was carried out in an evaporator composed of a bell provided with a system of pumping and piezoelectric quartz for the measurement of the thicknesses (Figure 1). Two types of targets were elaborated out with and without backing (self-supported target). The self-supported targets were produced by the use of a taking off agent which dissolves easily in distilled water. This agent depends on the material deposited. It should be pointed out that the crystalline shapes of both agent and material to deposit have to be similar.

### Determination of the thickness by piezoelectric quartz

Thickness can be measured during the evaporating procedure by a piezoelectric quartz crystal (silicon dioxide crystal) put on the sample in the enclosure of the evaporator. The quartz is subjected to a mechanical pressure during evaporation, giving appearance of an electric potential on its face. The measurement of the resonance frequency of this quartz which varies as function of the thickness allows the determination of the thickness of the target.

### RUTHERFORD BACKSCATTERING

Particles backscattering principle is shown in Figure 2.

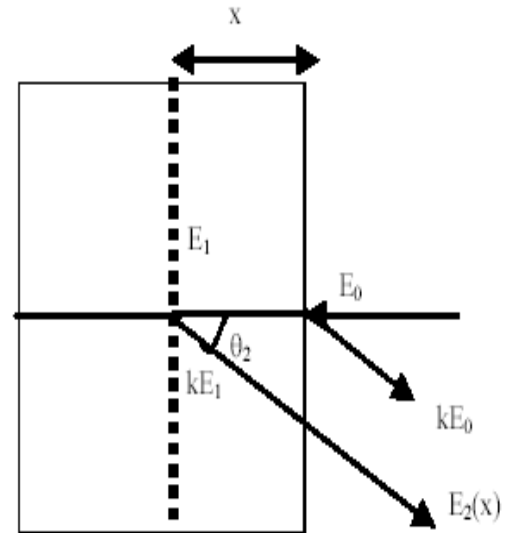


Figure 2. Principle of backscattering.

When a target of thickness  $x$  is bombarded with incident particles of energy  $E_0$ , their energy after diffusion, at an angle  $\theta$ , by the nuclei located at the surface of the target is  $kE_0$ , where  $k$  is the kinematic factor given by:

$$k = \left( \frac{M_1 \cos \theta + \sqrt{M_2^2 - M_1^2 \sin^2 \theta}}{M_1 + M_2} \right)^2 \quad (1)$$

$M_1$  ;  $M_2$  are the masses of incident particle and nucleus of the target,  $\theta$  being the diffusion angle.

After crossing the sample, the energy of the particle at a depth  $x$  is:

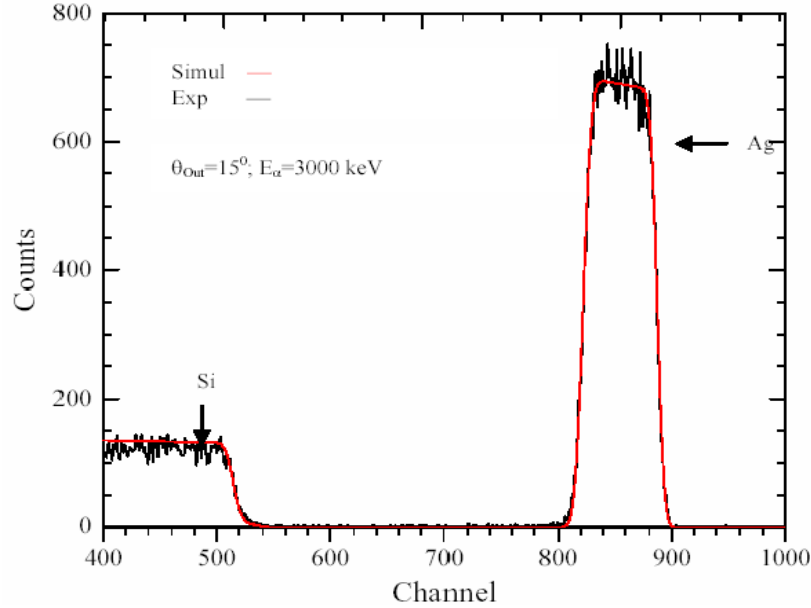
$$E_1 = E_0 - \int_0^x \frac{dE}{dx} dx \quad \text{for the ingoing path} \quad (2)$$

After backscattering on a nucleus of the target at the depth  $x$ , its energy will be:

$$E_2(x) = k E_1 - \int_0^x \frac{dE}{dx} dx \quad \text{for the outgoing path} \quad (3)$$

$\theta_2$  is the angle of the backscattered ion with the target's normal. The lost energy is then  $\Delta E = k E_0 - E_2$ . Using Equations 2 and 3, we found:

$$\Delta E = k \int_0^x \frac{dE}{dx} dx + \int_0^x \frac{dE}{dx} dx \quad (4)$$



**Figure 3.** Backscattered spectrum of alpha particles on silver target of 1990°A thickness with silicon backing.

$$\text{or } \Delta E = k \Delta E_{in} + \Delta E_{out}$$

Introducing the stopping power  $[S] = dE/dx$  and assuming that the energy lost  $dE/dx$  is constant and calculated at  $\bar{E}_{in}$  and  $\bar{E}_{out}$ , the integrals give:

$$\Delta E_{in} = [S(\bar{E}_{in})] \Delta x \quad \text{and} \quad \Delta E_{out} = \frac{1}{\cos \theta_2} [S(\bar{E}_{out})] \Delta x \quad (5)$$

Many approximations (Chu et al., 1978) allow calculating  $[S]$  and finally  $\Delta x$ .

- Approximating the surface energy for thin target as:

$$\bar{E}_{in} = E_0 - \frac{\Delta E_{in}}{2} \quad \text{and} \quad \bar{E}_{out} = k E_0 - \frac{\Delta E_{out}}{2} \quad (6)$$

- On the other hand, approximating the average energy for appreciable target thickness as:

$$\bar{E}_{in} = \frac{1}{2} (E_0 + E_1) \quad \text{and} \quad \bar{E}_{out} = \frac{1}{2} (k E_1 + E_2) \quad (7)$$

$E_1$  being unknown, one can suppose that the energy loss can be split symmetrically between the ingoing and the outgoing paths, so that  $\Delta E_{in} \approx \Delta E_{out}$  and thus the average energies will be:

$$\bar{E}_{in} = \left( E_0 + \frac{\Delta E}{4} \right) \quad \text{and} \quad \bar{E}_{out} = \left( E_2 + \frac{\Delta E}{4} \right) \quad (8)$$

Our measurements were done with alpha particles, produced by the Van de Graff accelerator. The backscattered particles were detected with a surface barrier detector. A typical backscattered spectrum is represented in Figure 3, showing the signal of the silicon backing and that of silver. The width at half maximum (FWHM) of the backscattered peak represents the total energy loss  $\Delta E$  of the ingoing and outgoing paths. The target thickness can be obtained from:

1. The ratio of the surface of the RBS spectrum of the element over the height of signal of the backing.
2. The analysis of the RBS spectrum with the RUMP code (Doolittle, 1985).
3. The determination of the energy  $E_1$  at depth  $x$  by a calculus code using different methods.

However, in this work the determination is limited to cases 1 and 2. Several samples were used:

1. Two samples Ag/Si of different thicknesses, a sample of Au/Ti/Si, and all three with two systems of detection to see if the detection angle influences the thickness determination of the target.
2. Three samples of Ag/Si of different thicknesses, two self supported targets of nickel and aluminium with only one detection system.

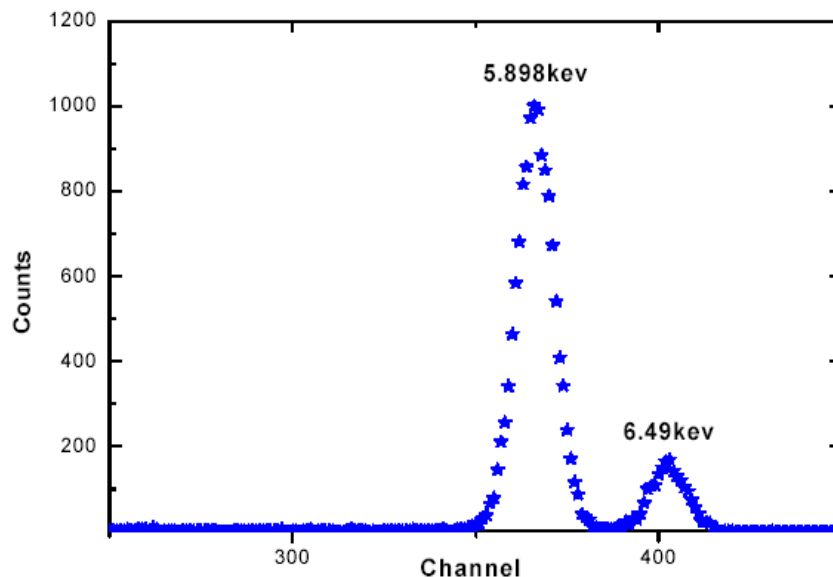


Figure 4.  $^{55}\text{Fe}$  spectrum without absorber.

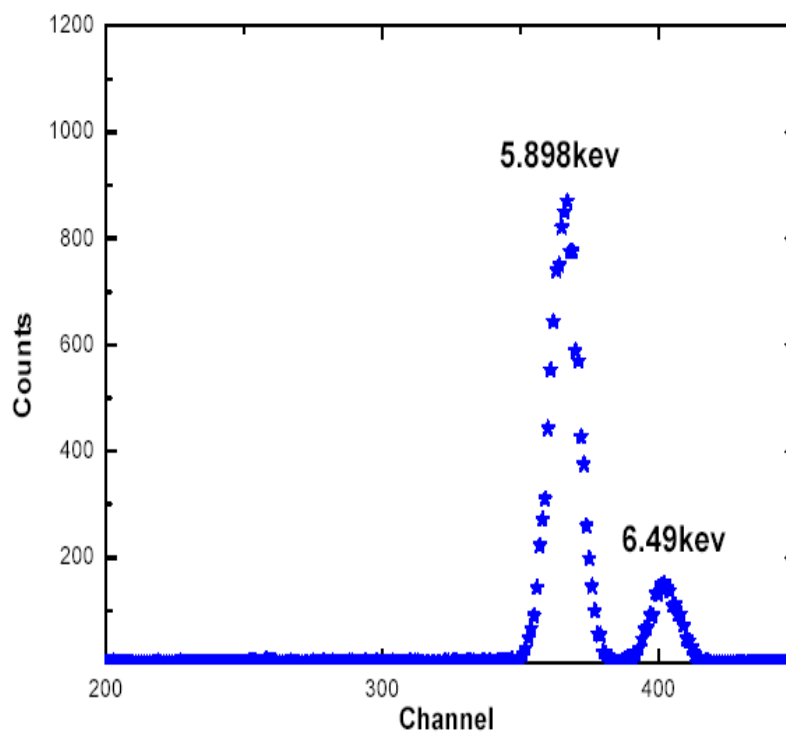


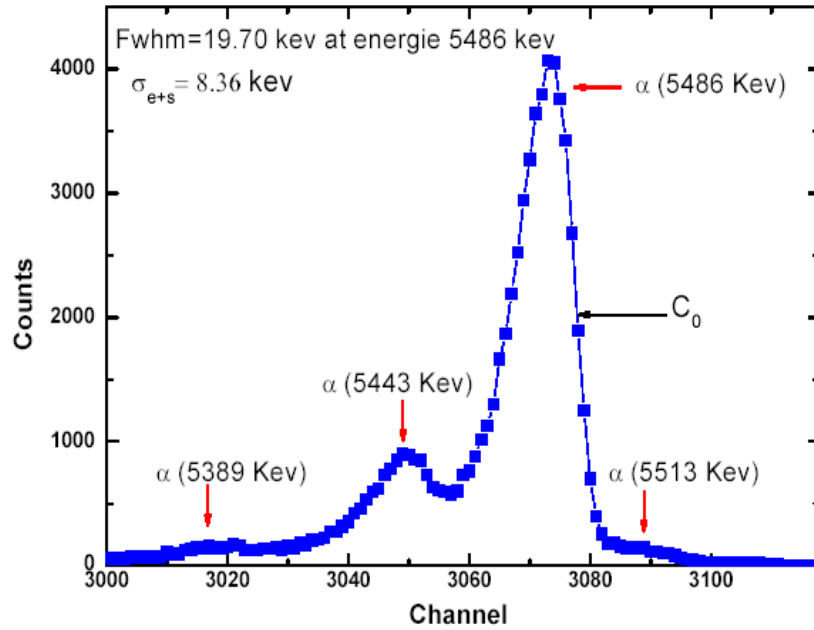
Figure 5.  $^{55}\text{Fe}$  spectrum with aluminium absorber.

#### METHOD OF ATTENUATION OF X-RAYS IN MATTER

Measurements of target thickness were also made from the attenuation of the photons. It is deduced from the Lambert's law (Davisson and Evans, 1952) according to which intensity  $I$  of the transmitted photons is given by the relation  $I = I_0 \exp(-\mu x)$  where  $I_0$  is the initial intensity,  $\mu$  the linear attenuation coefficient and  $x$  the

thickness of the absorber. The thickness is then  $x = (1/\mu) \ln(I_0/I)$ . We performed the experiment on two films of nickel and aluminium.

The X-rays are provided by a 25mCi sealed source of Iron ( $^{55}\text{Fe}$ ), emitting the 5,898 keV and 6,49 keV lines of manganese. The transmitted photons are collected in Si(Li) detector of 220 eV of resolution at 5,898 keV energy. The measurements were conducted three times and gave similar results. Figures 4 and 5



**Figure 6.** Spectrum of alpha particles issued from the  $^{241}\text{Am}$  source without absorber.

show typical X-ray spectra.

#### Technique by transmission of the $\text{He}^{++}$ particles from a $^{241}\text{Am}$ source

The technique consists in measuring the energy loss  $\Delta E$  of the alpha particles in self supported targets. The stopping power in the approximation of average energy  $E_M$  is obtained from code SRIM 2003 (Ziegler et al., 1985), used for the determination of targets thickness. The experimental energy loss is given by:

$$\Delta E[\text{keV}] = E_0 - E_1 = a * (C_0 - C_1) \quad (9)$$

where  $E_0$ ,  $E_1$  and  $C_0$ ,  $C_1$  are energies and the corresponding channels measured without and with the target,  $a$  [keV/channel] is the slope of the calibration straight line. The average energy is

$$E_M = E_0 - \frac{\Delta E}{2} \quad (10)$$

By using the stopping power  $[\varepsilon]$ , one can write

$$\varepsilon(E_M) [\text{keV/micron}] = (\Delta E/x) = a * (C_0 - C_1) / x \quad (11)$$

$[\varepsilon]$  is the stopping power at average energy  $E_M$ . We thus have

$$x[\mu\text{m}] = (\Delta E / \varepsilon(E_M)) \quad (12)$$

#### Measurements

The experimental set up is composed by an enclosure, the source, a pumping system and a chain of detection constituted by a  $50 \text{ mm}^2$  surface barrier detector with 12 keV of resolution at the 5486 keV

energy, a preamplifier and an amplifier. Alpha particles are provided by  $1 \mu\text{Ci}$   $^{241}\text{Am}$  source of 5486 keV energy. Measurements were carried out on targets of nickel and Aluminium manufactured and other aluminium and silver targets that we have realized in the Laboratory for Targets of CRNA. Figures 6 and 7 show spectra of alpha particles resulting from the  $^{241}\text{Am}$  source without absorber and after crossing a nickel target of  $1.27 \mu\text{m}$  thickness.

#### Transmission of the alpha particles provided by an accelerator

The same principle used for transmission for alpha particles resulting from the radioactive source is applied. The surface barrier detector is placed at a detection angle of  $30^\circ$  in order to avoid its deterioration. The experiment is carried out in combination with the RBS. The spectrum obtained is represented in Figure 8.

## RESULTS

The resulting thicknesses determined by the two methods; the ratio of the surface of the RBS spectrum of the element over the height of signal of the backing and the analysis of the RBS spectrum with the RUMP code (Doolittle, 1985), are reported in Table 1. We should note that the measurements, carried out with the method of the ratio of the height of the spectrum of the backing over the surface of the target, are not in agreement with the results obtained using the Rump code for samples 1 and 2; the signal of the silicon backing being not well defined because of its bad quality. However, results obtained for the sample 3 are of the same order of magnitude as those obtained with the Rump code. During the simulation by the Rump code for sample 1 and in the range of quoted energies (Table 1), we noticed a light

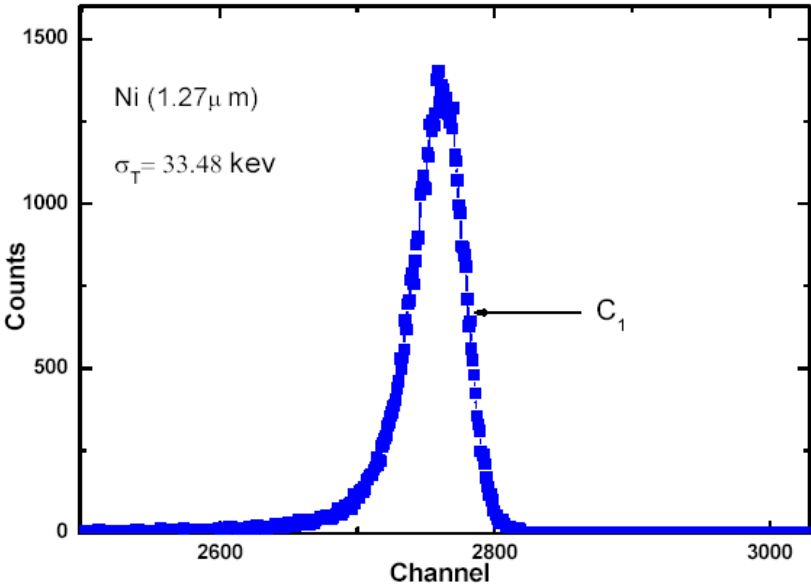


Figure 7. Spectrum of alpha particles after transmission through the absorber.

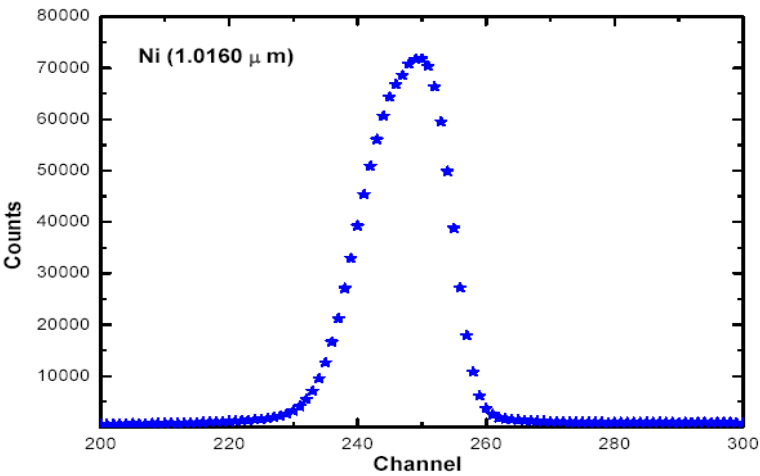


Figure 8. Transmitted alpha spectrum through Nickel target.

**Table 1.** Thicknesses determined by the method of the ratio of the height of the signal of the backing over that of the element and by simulation with Rump code.

Sample	Target	Energy range of alpha particles	Detection angle $\theta$	(surface of element target)/(Height of backing signal) (Å)	Rump(Å)
1	Ag/Si	[700kev-1100kev]	150°	691.5	1030
		[1200kev-1600kev]	165°	663.9	988
		[700kev-1600kev]	165°	722.5	1055
2	Ag/Si	[1600kev-3000kev]	150°	1587	1930
		[1600kev-3000kev]	165°	1591	1990
3	Au/Ti/Si	[1800kev-3400kev]	150°	1265	1230
			165°	1202	1210

**Table 2.** Thicknesses obtained with the piezo electric quartz and by the simulation with Rump code. (Q) measured by the piezo electric quartz, (C) given by the manufacturer.

Sample	Target	Energy (keV)	Detection angle $\theta$	Rump (Å)	Given thickness Quartz (Å)	Uncertainties (%)
4	Ag/Si	2000	160°	207	214 (Q)	4.02
5	Ag/Si	2000	160°	433	450 (Q)	3.73
6	Ag/Si	2000	160°	822	859 (Q)	4.31
7	Al	2200	165°	6836	7500 (C)	3.45
8	Ni	2200	165°	6150	6350 (C)	3.00

**Table 3.** Values for the attenuation coefficients  $\mu$ .

Elements	Z	$\mu(\text{m}^{-1})$
Aluminium	13	32721.22
Nickel	28	101586.61
silver	47	504693.87

**Table 4.** Measured thicknesses by the attenuation technique compared with those given by manufacturer (C).

Element	Z	Given thickness ( $\mu\text{m}$ )	Measured thickness ( $\mu\text{m}$ )	Relative uncertainties (%)
Nickel	28	0.635 (C)	0.627±0.019	3
		0.762 (C)	0.757±0.024	3
		1.905 (C)	1.879±0.025	1.3
		3.750 (C)	3.678±0.055	1.5
Aluminium	13	2.000 (C)	1.921±0.038	2
		4.000 (C)	3.780±0.109	3
Silver	47	5.000 (C)	4.818±0.094	2

variation of the thickness, which can be explained by the inclination and the non uniformity of the target. We can also see that the detection angle ( $\theta=150^\circ$  or  $\theta=165^\circ$ ) does not influence the thickness.

In Table 2, we report the results obtained with the Rump code for self supported targets of nickel, aluminum and for Ag on Si backing. The uncertainties given for the simulation of the spectrum are estimated from the uncertainty on the channel; the resolution of the detector and on the stopping power. The comparison between the values measured with piezoelectric quartz, those obtained with RUMP code and those given by the manufacturer for Ag/Si targets and Nickel indicates a good agreement, except for the aluminium foil for which the light difference can be attributed to the value given by the manufacturer.

Measurements of target thickness were made from the attenuation of the photons using the values for the attenuation coefficients (Berger and Hubbell, 1987) given in the Table 3 for the energy 5,898 keV, we find the results in Table 4. The uncertainties were calculated using the Lambert's law, taking into account the precision

on the intensity of the source before and after attenuation ( $<3\%$ ), and the error on the attenuation coefficient (1% for aluminium). They were also made from the technique by transmission of the  $\text{HE}^{++}$  particles from a  $^{241}\text{Am}$  source; the results are reported in the Table 5. The uncertainties were calculated using the equation:

$$\frac{\Delta x}{x} = \frac{\Delta \varepsilon}{\varepsilon} + \frac{\Delta(\Delta E)}{\Delta E}$$

taking into account the precisions of the stopping power (2%) and the energy lost ( $<0.5\%$ ).

#### Comparison between the thickness measured by transmission of alpha particles given by radioactive source and produced by accelerated particles

The results of the measurements are reported in Table 6. We can notice that the values obtained by transmission of the particles alpha produced by the  $^{241}\text{Am}$  radioactive source (Table 5) or coming from the accelerator (Table 6)



**Table 5.** Measured thicknesses by transmission of alpha particles: (•) prepared in this work (C) manufactured (P) measured by piezoelectric quartz.

Element	Z	$\Delta E$ (keV)	Given thickness ( $\mu\text{m}$ )	Thickness measured by transmission ( $\mu\text{m}$ )	Uncertainties (%)
Ni	28	264.799	0.635 (c)	0.68 $\pm$ 0.03	4.4
		321.290	0.762 (c)	0.82 $\pm$ 0.04	4.8
		434.271	1.016 (c)	1.10 $\pm$ 0.05	4.5
		524.303	1.270 (c)	1.32 $\pm$ 0.06	4.5
		835.001	1.905 (c)	2.07 $\pm$ 0.09	4.3
Ag	47	54.725	•0.155 (P)	0.16 $\pm$ 0.008	5.0
Al	13	81.205	•0.500 (P)	0.52 $\pm$ 0.03	5.7
		112.981	0.750 (C)	0.73 $\pm$ 0.04	5.4
		631.988	4.000 (C)	3.95 $\pm$ 0.2	5.0

**Table 6.** Measured thicknesses by transmission of 2.2 MeV alpha particles coming from an accelerator (C) thickness given by the manufacturer.

$\Delta E$ (keV)	$\Delta E/E_0$ (%)	Given thickness ( $\mu\text{m}$ )	Measured thickness ( $\mu\text{m}$ )	Relative uncertainties (%)
434.696	19.759	0.635 (c)	0.65 $\pm$ 0.03	4.6
547.865	24.903	0.762 (c)	0.81 $\pm$ 0.05	6.1
744.422	33.837	1.016 (c)	1.08 $\pm$ 0.08	7.4
833.766	37.899	1.270 (c)	1.21 $\pm$ 0.06	5.0
1298.354	59.016	1.905 (c)	1.81 $\pm$ 0.17	9.3

are in agreement with the values given by the manufacturer or those measured by the piezoelectric quartz.

We can see on the Table 5 that for the thicknesses lower than 1.2  $\mu\text{m}$ , the results by transmission of the alpha particles given by the radioactive source and those produced by the accelerator (Table 6) are similar. For the thicknesses above 1.2  $\mu\text{m}$ , the difference between the two measurements can be explained by the use of the approximation of average energy in the calculation of the stopping power for the 2200 keV energy of the alpha particles given by the accelerator, the total energy loss is of 833 keV, the approximation of average energy for the calculation of the stopping power is not good whereas for the alpha particles provided by the source, the energy loss being small, the approximation is more suitable.

## Conclusion

In the aim of selecting the technique allowing the thickness determination of a target with the best possible precision, several methods of measurement have been investigated. According to the relative uncertainties made

in the determination of the targets thicknesses, the followings can be concluded:

1. The method by attenuation of X-rays is preferable to the other methods for its precision and its simplicity, mainly for large thicknesses, since we found that the uncertainties on the thickness are lower than 3%. This technique is currently used in industry for the measurement of the thicknesses of different materials.
2. In the case of a target deposited on a backing, where the method by attenuation cannot be employed, RBS technique remains the method suitable compared to the two techniques by the attenuation of X-ray and the transmission of the alpha. Only one must take into account that the uncertainties made on the thickness of the target varies between 4 to 6%. This technique is used simultaneously with the PIXE analysis technique (which requires the knowledge of the thicknesses to obtain the absolute concentrations).

In conclusion, the attenuation of X-rays remains the best technique for the determination of large thicknesses targets with a better precision for the self supported ones whereas for very thin targets deposited on a backing, RBS technique remains a good method, since the

difficulty of the self supported thin targets lies in their brittleness to handle them manually and in the fact that certain metal elements of the periodic table cannot be put always in the form of self supported targets.

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## REFERENCES

- Berger MJ, Hubbell JH (1987). XCOM: Photon Cross Sections. NBSIR pp. 87-3597.
- Chu WK, Mayer JM, Nicolet MA (1978). Backscattering Spectrometry. Academic Press. New York.
- Davisson CM, Evans BD (1952). Gamma-ray absorption coefficients. Rev. Mod. Phys. 24(2).
- Doolittle LR (1985). Code of simulation RUMP. Nucl.Inst.and Meth. B. 9:291.
- Ekinici N, Valles Jr JM (2001). Determination of thin film thickness by X-ray transmission. 16th International Conference on X-ray Optics and Microanalysis (ICXOM). Vienna.
- Johansson SE, Campbell JL (1970). (Provide work title). John Wiley and Sons, P. 87.
- Ourabah S, Amokrane A (2006). Conference Nationale de la Physique et de ses Applications, Béchar Algérie.
- Tran CQ, Chantler CT, Barnea Z, de Jonge MD, Dhal BB (2002). Accurate determination of the thickness of thin specimens and applications in X-rays Attenuation measurements . European Conference on Energy Dispersive X ray Spectrometry. Berlin, Germany. P.12.
- Ziegler JF, Biersack JP, Littmark U (1985). The stopping and ranges of ions in matter.1. New York. www.srim2003.org.

Full Length Research Paper

## ***trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H)<sub>2</sub>]: a platinum complex forming a two-dimensional hydrogen-bonded network**

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The compound *trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H)<sub>2</sub>] has been prepared from the hydrolysis of a platinum diimine complex, and has been characterised by X-ray crystallography. The crystal structure revealed that the compound forms a two-dimensional hydrogen-bonded network in the solid state, with pairs of O–H...O hydrogen bonds between carboxylic acid groups linking the molecules into zigzag tapes, which are cross-linked into sheets by pairs of N–H...Cl hydrogen bonds.

**Key words:** Metal-organic frameworks, metalloligands, two-dimensional hydrogen-bonded network.

### INTRODUCTION

Coordination networks, otherwise known as metal-organic frameworks (MOFs) (Rowsell and Yaghi, 2004; Kitagawa et al., 2004; Férey, 2008; Robson, 2008) are currently attracting considerable interest for a wide range of potential applications (Czaja et al., 2009; Gagnon et al., 2012). Many robust, highly porous MOFs have been prepared that may be particularly useful in gas storage and separations (Rosi et al., 2003; Chae et al., 2004; Bennett et al., 2001). A major challenge in the field is the introduction of complex functionality (e.g., catalysis, luminescence, etc.) into MOF assemblies (Hupp and Poeppelmeier, 2005; Wu et al., 2005, 2004; Kitagawa et al., 2004). Efforts to introduce more complex functionality include modification of the ligand structure and forcing sites of unsaturation or labile solvent coordination at the metal nodes. Among the most attractive strategies for introducing new functionality is the use of “metalloligands”—metal complexes that contain ligands that have uncoordinated donor sites that can themselves act as ligands in MOF synthesis. This strategy has enabled the preparation of bimetallic MOFs, in which different metal centres may have different structural and/or functional roles (Noro et al., 2002; Kitaura et al.,

2004; Vreshch et al., 2004; Chen et al., 2004; Halper et al., 2006; Burrows et al., 2007, 2008; Zhang et al., 2008; Garibay et al., 2009). We were interested in preparing bimetallic MOFs by adopting a “two-step self-assembly” approach, where a metalloligand is synthesized in the first step as a framework linker, and then in the second step, the metalloligand is added to another metal ion, which acts as a node in the framework. By using the platinum diimine complex 1 (Buffin and Kundu, 2003), as a metalloligand in MOF construction, we were able to isolate crystals of *trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H)<sub>2</sub>]<sub>2</sub>, which had formed as a decomposition product of 1. Here we report the characterization of this new platinum(II) complex, which has a two-dimensional hydrogen bonded network in the solid state.

### EXPERIMENTAL

Platinum(II) chloride (0.027 g, 0.1 mmol) and 4-aminobenzoic acid (0.027 g, 0.2 mmol) were added to water (2.7 cm<sup>3</sup>) and THF (4 cm<sup>3</sup>) in a pressure tube, and the mixture was heated at 95°C for 5 days. On cooling to room temperature, crystals of 2 suitable for single

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**Table 1.** Crystal data and structure refinement for *trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H)<sub>2</sub>] **2**.

Empirical formula	Cl <sub>4</sub> H <sub>4</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>4</sub> Pt
Formula weight	540.26
Temperature	173(2) K
Wavelength	0.71073 Å
Crystal system	Triclinic
Space group	<i>P</i> -1
Unit cell dimensions	
<i>a</i> =	4.9020(1) Å
<i>b</i> =	5.7840(2) Å
<i>c</i> =	13.5710(4) Å
$\alpha$ =	87.0040(1)°
$\beta$ =	88.1620(1)°
$\gamma$ =	89.553(2)°
Volume	384.050(19) Å <sup>3</sup>
<i>Z</i>	1
Density (calculated)	2.336 mg/m <sup>3</sup>
$\mu$	9.503 mm <sup>-1</sup>
<i>F</i> (000)	256
Crystal size	0.37 × 0.37 × 0.05 mm <sup>3</sup>
Theta range for data collection	3.01 to 27.42°.
Index ranges	-6 ≤ <i>h</i> ≤ 6, -7 ≤ <i>k</i> ≤ 7, -17 ≤ <i>l</i> ≤ 17
Reflections collected	5396
Independent reflections	1747 [ <i>R</i> (int) = 0.0765]
Completeness to theta = 27.42°	99.0 %
Refinement method	Full-matrix least-squares on <i>F</i> <sup>2</sup>
Data / restraints / parameters	1747 / 0 / 109
Goodness-of-fit on <i>F</i> <sup>2</sup>	1.033
Final <i>R</i> indices [ <i>I</i> > 2σ( <i>I</i> )]	<i>R</i> <sub>1</sub> = 0.0584, <i>wR</i> <sub>2</sub> = 0.1514
<i>R</i> indices (all data)	<i>R</i> <sub>1</sub> = 0.0583, <i>wR</i> <sub>2</sub> = 0.1514
Largest diff. peak and hole	5.885 and -3.954 e.Å <sup>-3</sup>

crystal X-ray analysis were obtained. <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>) δ 7.82 (d 4H), 7.28 (d 4H), 3.48 (br 2H), <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>) δ 167.82, 153.43, 131.55, 117.28, 112.94. Found: C, 30.2; H, 2.19; N, 5.36%. C<sub>14</sub>H<sub>15</sub>N<sub>2</sub>O<sub>4.5</sub>PtCl<sub>2</sub> (2·0.5H<sub>2</sub>O) requires C, 30.6; H, 2.75; N, 5.10%.

diffractometer. Details of the X-ray crystallographic analysis are given in Table 1. Fractional coordinates for the refined atoms and equivalent isotropic thermal parameters are presented in Table 2. The crystal structure was solved using SHELXS-97 and refined using SHELXL-97.

## NMR

The <sup>1</sup>H NMR and <sup>13</sup>C NMR spectra of the complex were recorded with a Bruker Advance 300 instrument using *d*<sub>6</sub>-DMSO solutions and TMS as internal standard.

## Elemental analysis

The C, N and H content of the compounds were determined using a CE-440 Elemental Analyser by Alan Carver at the University of Bath.

## Structural analysis

The structural data were collected on a Nonius KappaCCD

## RESULTS AND DISCUSSION

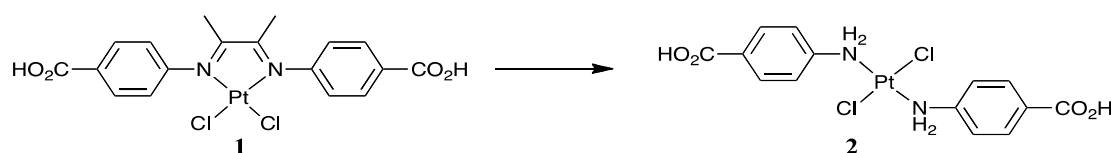
While investigating the use of the platinum diimine complex **1** (Buffin and Kundu, 2003) as a metalloligand in MOF construction, we were able to isolate crystals of *trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H-4)<sub>2</sub>] **2**, which had formed as a decomposition product of **1** (Scheme 1). Following identification of **2**, it was found possible to produce this compound *via* a more rational approach by reacting platinum(II) chloride with 4-aminobenzoic acid in a mixture of water and THF. Crystals of **2** were analysed by single crystal X-ray crystallography.

The asymmetric unit of **2** consists of half a platinum

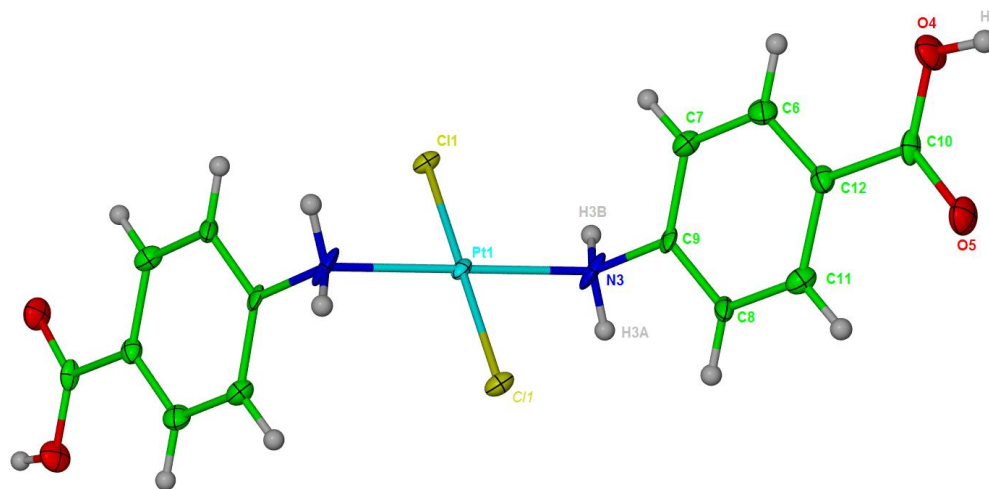
**Table 2.** Atomic coordinates ( $\times 10^4$ ) and equivalent isotropic displacement parameters for ( $\text{\AA}^2 \times 10^3$ ) for *trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H)<sub>2</sub>] 2.

Parameter	x	y	z	U(eq)
Pt(1)	10000	10000	0	11(1)
N(3)	11248(19)	7842(16)	1162(9)	19(2)
O(4)	2465(19)	7160(17)	4770(7)	24(2)
O(5)	1603(19)	3909(17)	4003(7)	24(2)
C(6)	6610(20)	8390(20)	3355(9)	20(2)
C(7)	8620(20)	8900(20)	2638(9)	18(2)
C(8)	7770(20)	5271(19)	1896(8)	16(2)
C(9)	9220(20)	7332(18)	1920(8)	14(2)
C(10)	2910(20)	5750(20)	4088(8)	15(2)
C(11)	5710(20)	4780(20)	2597(9)	18(2)
C(12)	5130(20)	6337(19)	3343(8)	15(2)
Cl(1)	13162(5)	12603(4)	460(2)	15(1)

U(eq) is defined as one third of the trace of the orthogonalized  $U^{ij}$  tensor



**Scheme 1.** Formation of 2 from the decomposition of 1.



**Figure 1.** Molecular structure of *trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H)<sub>2</sub>] 2.

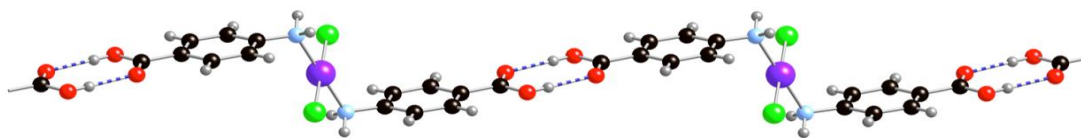
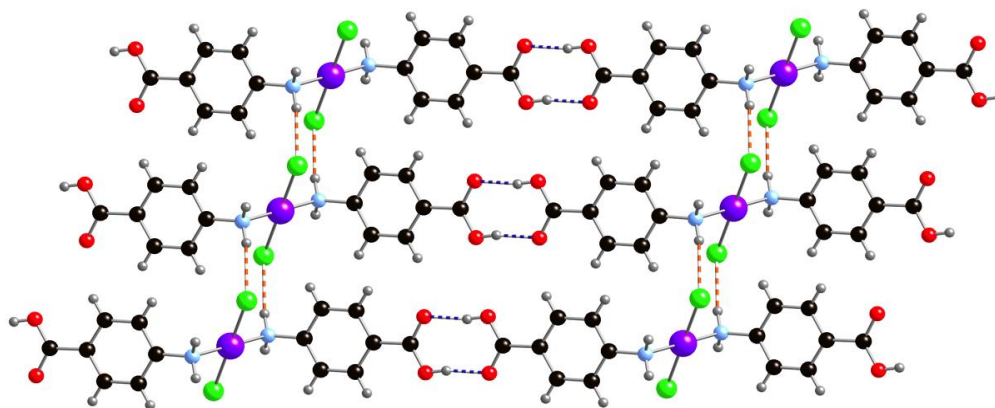
atom, a coordinated chloride ion and a 4-aminobenzoic acid molecule that is coordinated to the platinum centre through the nitrogen atom. The partial-occupancy platinum atom resides on an inversion centre, which serves to generate the remainder of the molecule. The molecular structure of 2 is shown in Figure 1. The

structural analysis revealed that the platinum centre has the expected distorted square planar geometry (Table 3), with *cis* angles of 87.4(3) and 92.6(3)°. The Pt–N and Pt–Cl bond distances (2.057(10) and 2.293(2) Å respectively) lie within the expected ranges (Orpen et al., 1989). The only previous structurally characterised

**Table 3.** Selected bond lengths (Å) and angles (°) for 2.

Pt(1)–N(3)	2.057(10)
Pt(1)–Cl(1)	2.293(2)
O(4)–C(10)	1.275(15)
O(5)–C(10)	1.263(15)
N(3)–C(9)	1.435(14)
N(3)–Pt(1)–Cl(1)	87.4(3)
N(3)–Pt(1)–Cl(1)'	92.6(3)
C(9)–N(3)–Pt(1)	115.4(6)

Primed atoms generated by the symmetry operation  $-x + 2, -y + 2, -z$ .

**Figure 2.** Zigzag hydrogen-bonded tapes in the supramolecular structure of *trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H)<sub>2</sub>] 2.**Figure 3.** Hydrogen-bonded sheets present in the supramolecular structure of *trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H)<sub>2</sub>] 2.

example of a dichlorobis(phenylamine)platinum complex contains 2-(3-aminophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (Vogels et al., 1999), and this has a very similar coordination geometry, with identical bond lengths and angles [Pt–Cl 2.290 Å, Pt–N 2.053 Å, N–Pt–Cl 88.1, 91.9°].

Each carboxylic acid group in 2 forms a hydrogen bonded dimer with the equivalent group on a neighbouring molecule with the parameters O(4)⋯O(5) 2.612 Å, H(4)⋯O(5) 1.78 Å, O(4)–H(4)⋯O(5) 170° [O(5) generated by the symmetry operation  $-x, -y + 1, -z + 1$ ]. The carboxylic acid dimer, described by the graph set R<sup>2</sup><sub>2</sub>(8) (Bernstein et al., 1995), is a common motif in crystal engineering, where there is an absence of

competing donors and acceptors (Allen et al., 1999; Ayi et al., 2001; Burrows, 2004), and in the case of 2, these hydrogen bonds link the molecules into zigzag tapes, as shown in Figure 2. The zigzag nature of the tapes arises from the platinum coordination plane and the aminobenzoic acid ligand being non-coplanar, as evidenced by 107° angle between the mean plane containing Pt(1), Cl(1) and N(3), and that containing N(3), C(6)–C(12), O(4) and O(5).

Additional hydrogen bonds between the coordinated amine groups and one of the chloride ligands link the chains into a two-dimensional network, shown in Figure 3. The N–H⋯Cl hydrogen bonds occur pairwise, generating R<sup>2</sup><sub>2</sub>(8) rings with the hydrogen bonding

parameters N(3)···Cl(1) 3.339 Å, H(3A)···Cl(1) 2.43 Å, N(3)–H(3A)···Cl(1) 172° [Cl(1) generated by the symmetry operation  $x, y - 1, z$ ]. These parameters are within the expected range for N–H···Cl interactions when the chloride is coordinated to a metal (Brammer, 2003; Brammer et al., 2001). There are no significant interactions between the sheets, and neither the amino hydrogen atom H(3B) nor the chlorine atom Cl(2) is involved in hydrogen bond formation.

In conclusion, a new platinum(II) complex of aminobenzoic acid, *trans*-[PtCl<sub>2</sub>(NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CO<sub>2</sub>H-4)<sub>2</sub>] 2, has been prepared under mild hydrothermal conditions and structurally characterized. A study of 2 as a metalloligand in the formation of mixed-metal MOFs is currently underway.

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## REFERENCES

- Allen FH, Motherwell WDS, Raithby PR, Shields GP, Taylor R (1999). Systematic analysis of probabilities of formation of bimolecular hydrogen-bonded ring motifs in organic crystal structures. *New J. Chem.* 23:25-34.
- Ayi AA, Choudhury A, Natarajan S, Rao CNR (2001). Cyclic acetate dimers formed by C–H···O hydrogen bonds in an open-framework zinc phosphate-acetate. *New J. Chem.* 25:213-215.
- Bennett MV, Beauvais LG, Shores MP, Long JR (2001). Expanded Prussian Blue Analogues Incorporating [Re<sub>6</sub>Se<sub>8</sub>(CN)<sub>6</sub>]<sup>3-/4-</sup> Clusters: Adjusting Porosity via Charge Balance. *J. Am. Chem. Soc.* 123:8022-8032.
- Bernstein J, Davis RE, Shimon L, Chang NL (1995). Patterns in hydrogen bonding: Functionality and graph set analysis in crystals. *Angew. Chem. Int. Ed. Engl.* 34:1555-1573.
- Brammer L (2003). Metals and hydrogen bonds. *Dalton Trans.* 3145–3157.
- Brammer L, Bruton EA, Sherwood P (2001). Understanding the Behavior of Halogens as Hydrogen Bond Acceptors. *Cryst. Growth Des.* 1:277-290.
- Buffin B, Kundu A (2003). Synthesis, characterization, and crystal structure of platinum(II) and palladium(II) chlorides with an acidic  $\alpha$ -diimine ligand. *Inorg. Chem. Commun.* 6:680-684.
- Burrows AD (2004). Crystal Engineering Using Hydrogen Bonds. *Struct. Bonding* 108:55-96.
- Burrows AD, Cassar K, Mahon MF, Warren JE (2007). The stepwise formation of mixed-metal coordination networks using complexes of 3-cyanoacetylacetate. *Dalton Trans.* 2499-2509.
- Burrows AD, Mahon MF, Wong CTF (2008). Complexes as metalloligands in network formation: synthesis and characterization of a mixed metal coordination network containing palladium and zinc. *Cryst. Eng. Comm.* 10:487-489.
- Chae HK, Siberio-Pérez DY, Kim J, Go Y, Eddaoudi M, Matzger AJ, O'Keeffe M, Yaghi OM (2004). A route to high surface area, porosity and inclusion of large molecules in crystals. *Nature.* 427:523-527.
- Chen B, Fronczek FR, Maverick A (2004). Porous Cu–Cd mixed metal-organic Frameworks constructed from Cu(Pyac)<sub>2</sub>[Bis[3-(4-pyridyl)pentane-2,4-dionato]copper(II)]<sub>2</sub>. *Inorg. Chem.* 43:8209-8211.
- Czaja AU, Trukhan N, Müller U (2009). Industrial applications of metal-organic frameworks. *Chem. Soc. Rev.* 38:1284-1293.
- Férey G (2008). Hybrid porous solids: past, present, future. *Chem. Soc. Rev.* 37:191-214.
- Gagnon KJ, Perry HP, Clearfield A (2012). Conventional and Unconventional Metal-Organic Frameworks Based on Phosphonate Ligands: MOFs and UMOFs. *Chem. Rev.* 112:1034-1054.
- Garibay SJ, Stork JR, Cohen SM (2009). The Use of Metalloligands in Metal-Organic Frameworks. *Prog. Inorg. Chem.* 56: 335-378.
- Halper SR, Do L, Stork JR, Cohen SM (2006). Topological Control in Heterometallic Metal-Organic Frameworks by Anion Templating and Metalloligand Design. *J. Am. Chem. Soc.* 128:15255-15268.
- Hupp JT, Poepelmeier KR (2005). Better Living through Nanopore Chemistry. *Science* 309:2008-2009.
- Kitagawa S, Kitaura R, Noro SI (2004). Functional Porous Coordination Polymers. *Angew. Chem. Int. Ed.* 43:2334-2375.
- Kitaura R, Onoyama G, Sakamoto H, Matsuda R, Noro SI, Kitagawa S (2004). Immobilization of a Metallo Schiff Base into a Microporous Coordination Polymer. *Angew. Chem. Int. Ed.* 43:2684-2687.
- Noro S, Kitagawa S, Yamashita M, Wada T (2002). New microporous coordination polymer affording guest-coordination sites at channel walls. *Chem. Commun.* pp. 222-223.
- Orpen A, Brammer L, Allen F, Kennard O, Watson DG, Taylor R (1989). Supplement. Tables of bond lengths determined by X-ray and neutron diffraction. Part 2. Organometallic compounds and coordination complexes of the d- and f-block metals. *J. Chem. Soc. Dalton Trans.* S1-S83.
- Robson R (2008). Design and its limitations in the construction of bi- and poly-nuclear coordination complexes and coordination polymers (aka MOFs): a personal view. *Dalton Trans.* 5113-5131.
- Rosi NL, Eckert J, Eddaoudi M, Vodak DT, Kim J, O'Keeffe M, Yaghi OM (2003). Hydrogen storage in microporous Metal-Organic Frameworks. *Science* 300:1127-1129.
- Rowell J, Yaghi O (2004). Metal-organic frameworks: a new class of porous materials. *Micropor. Mesopor. Mat.* 73:3-14.
- Vogels CM, Wellwood HL, Biradha K, Zaworotko MJ, Westcott SA (1999). Reactions of aminoboron compounds with palladium and platinum complexes. *Can. J. Chem.* 77:1196-1207.
- Vreshch V, Lysenko A, Chernega A, Howard J, Krautscheid H, Sieler J, Domasevitch K (2004). Extended coordination frameworks incorporating heterometallic squares. *Dalton Trans.* 2899-2903.
- Wu CD, Hu A, Zhang L, Lin WB (2005). A Homochiral Porous Metal-Organic Framework for Highly Enantioselective Heterogeneous Asymmetric Catalysis. *J. Am. Chem. Soc.* 127:8940-8941.
- Wu CD, Ngo HL, Lin WB (2004). Luminescent homochiral silver(I) lamellar coordination networks built from helical chains. *Chem. Commun.* pp. 1588-1589.
- Zhang Y, Chen B, Fronczek FR, Maverick AW (2008). A nanoporous Ag-Fe mixed metal-organic framework exhibiting single-crystal-to single-crystal transformation upon guest exchange. *Inorg. Chem.* 47:4433-4435.



Full Length Research Paper

## Studies on drying rates of brined and spiced *Clarias gariepinus* (Catfish) using solar dryer

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The objective of this study was to determine the effect of brining and spicing with ginger or garlic on the drying rate of cat fish in a passive solar dryer. Samples of cat fish were solar dried under three different conditions: brine only, spiced with garlic and spiced with ginger. Their respective weight losses were used to determine the reduction in moisture contents. Graphs of drying rate versus time were plotted in each case and used to obtain the drying rate constant,  $k$  for the three drying conditions. This procedure is useful when a given level of moisture content must be linked to time of drying under similar conditions. The results obtained showed that cat fish dried using brine solution only is the best since its drying rate constant has the highest value of 0.375 units per day followed by ginger (0.273 units per day) and then garlic (0.254 units per day) is the least. The results also show that spicing with ginger and garlic reduce the drying rate of cat fish when dried in a passive solar dryer.

**Key words:** Comparative, drying, solar, rate, brine, ginger, garlic, fish.

### INTRODUCTION

The importance of fish in Nigeria lies in its contribution to food and financial security. Fish provides a good source of readily digested high quality animal protein together with a high concentration of vitamins A and D, a significant source of phosphorous and iron, as well as high concentrations of calcium in the bones, (Choo and Williams, 2003). In addition, the annual fish harvest fluctuates seasonally, with periods of high and low supply. During the periods of high supply, a lot of fish is spoilt and wasted, while acute shortage and increased costs of fish are experienced in periods of low harvest. According to Orengoh and Kisumo (2007), 50% of total annual fish harvest goes to waste due to poor treatment, management and storage. Fish spoilage is due to three main factors: Activity of micro-organisms (bacteria, moulds and yeast), chemical deterioration due to enzymatic activity (break-down of oils and fats that is, rancidity), attack by insects (blowfly and beetle

infestations) and vermin (UNIFEM, 1988; Ogunja et al., 1992). In order to reduce the wastage and spoilage of fish during periods of oversupply, and to enhance long storage, it is necessary to adopt appropriate as well as affordable processing and preservation techniques for fish especially in the artisanal fishermen's environment. Now that fish resources are frequently over-exploited there is increasing emphasis on up-grading post-harvest technologies (UNIFEM, 1988).

Dry salting, open-air sun drying, deep frying and smoking constitute the most common methods of fish processing and preservation for rural fishermen. The last two methods contribute to environmental degradation, since they use biomass, while smoking introduces cancer causing substances in fish flesh (Delgado et al., 2005). Drying of fish by sun or solar-dryers would offer alternative methods to smoking and deep frying dryers. Drying reduces or completely eliminates physiological,

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microbial and enzymatic degradation of biological materials such as fish (Shitanda and Wanjala, 2006). The disadvantages of open-air sun-drying of fish include destruction by birds, animals and man, contamination by excreta from birds and animals, soiling, fungal growth and mycotoxins, loss of nutrients, intensive labour and a large area requirement, while drying in solar dryers shields fish from agents of contamination and destruction and accelerates rate of drying. Several works have been reported on the development and evaluation of solar dryers to mitigate the limitations of open-air sun drying (Ojike et al., 2009; Ekechukwu and Norton, 1999; Muthuveerappan et al., 1985; Sadykov and Khairoddinov, 1982; Shaw, 1981). Solar drying combines the advantages of traditional open-air drying and industrial methods. This according to Whitefield (2000) requires low investment costs but yields high product quality. The use of solar drying systems by farmers is still unpopular in Nigeria.

Sodium chloride has traditionally been used in curing and preservation of meat and fish due to its capacity to improve the water holding capacity of proteins. While brining reduces the micro-organisms count on dry fish. Studies by Oliveira et al. (2006) and Graivier et al. (2006) indicated that high concentrations of salt used in osmotic dehydration are beyond the permissible levels for human consumption. Therefore, limiting the amount of salt used in brining, and subsequently dehydrating fish with a solar dryer would probably achieve a more stable and suitable dried fish product than carrying out separate osmotic dehydration or solar drying. Most a times brined fish are spiced with substances like ginger and garlic to add among other things flavour to the stored fish. The objective of this study is therefore to evaluate the effect of brine, ginger, and garlic solutions on the drying rate constant of cat fish when dried in a solar dryer. The contribution of this study will then be to discourage the use of smoking as a drying process for fish while replacing it with solar dryers which are more environmentally friendly in-addition to the effect of brining the dried fish.

## MATERIALS AND METHODS

### Description of the solar dryer system

A model of passive solar dryers developed at the National Centre for Energy Research and Development, University of Nigeria, Nsukka was used for this study. The solar dryer used was of natural convection type as shown in Figure 1a and b.

### The brining process of fish

Cat fish was procured from a fishpond in University of Nigeria, Nsukka, then eviscerated, de-scaled and thoroughly washed, its heads removed, split open longitudinally and cut into small pieces of approximately 4 cm by 3 cm by 1 cm. Three pieces of fish were used to evaluate the initial moisture content of the fish by using

MB 35 Halogen moisture meter. The remaining pieces, divided into three sets of samples, and were soaked in 50° brine solution for 12 h. Then a set was spiced with 2 g of grounded ginger and another spiced with 2 g of grounded garlic. Then a set was pickled in ginger solution and another in garlic solution. After brining and pickling, three pieces of fish from each treatment were used to determine the moisture content before solar drying. When all the three sets were placed in the solar dryer, the weight loss which was assumed to be only moisture loss was monitored periodically by weighing the samples until the weight was constant. The quantity of water removed during drying was determined by periodic weighing of the samples using the electronic balance, at one hour intervals for ten hours each day until the weight was constant. It was used to determine moisture content periodically. The ambient and chamber temperatures and relative humidity throughout the duration of the process were measured using Vaisala humidity and temperature indicator and I-BK precision thermocouple. These temperature and relative humidity instruments were placed just above the midpoint of the tray in the dryer. The data collected was used to plot graphs of moisture content and moisture ratio against drying time.

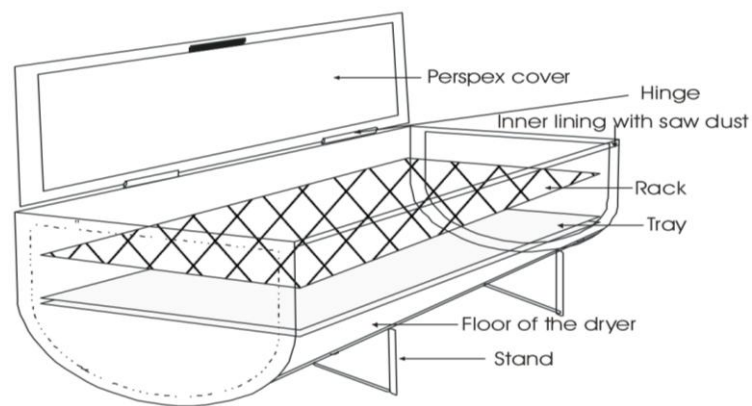
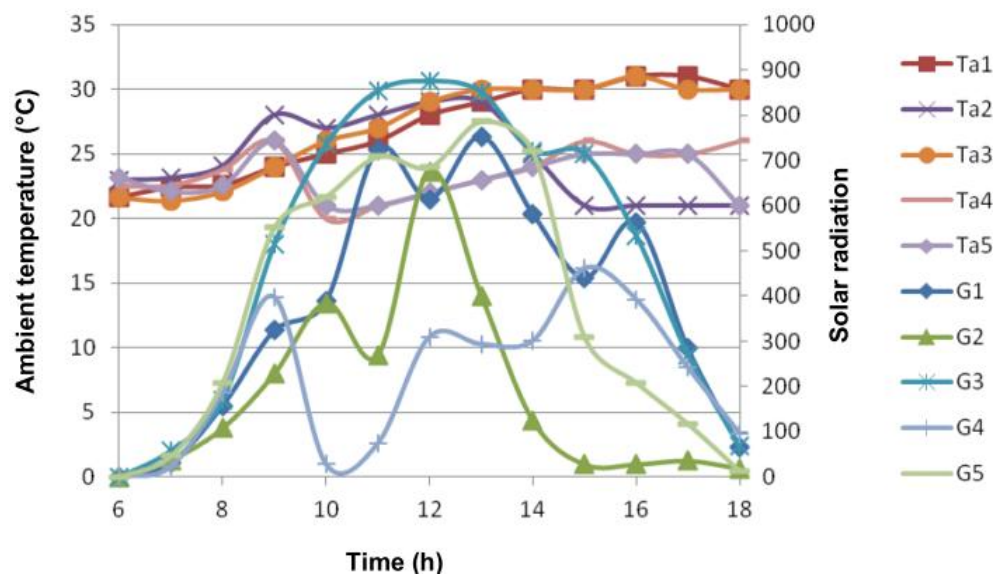
## RESULTS AND DISCUSSION

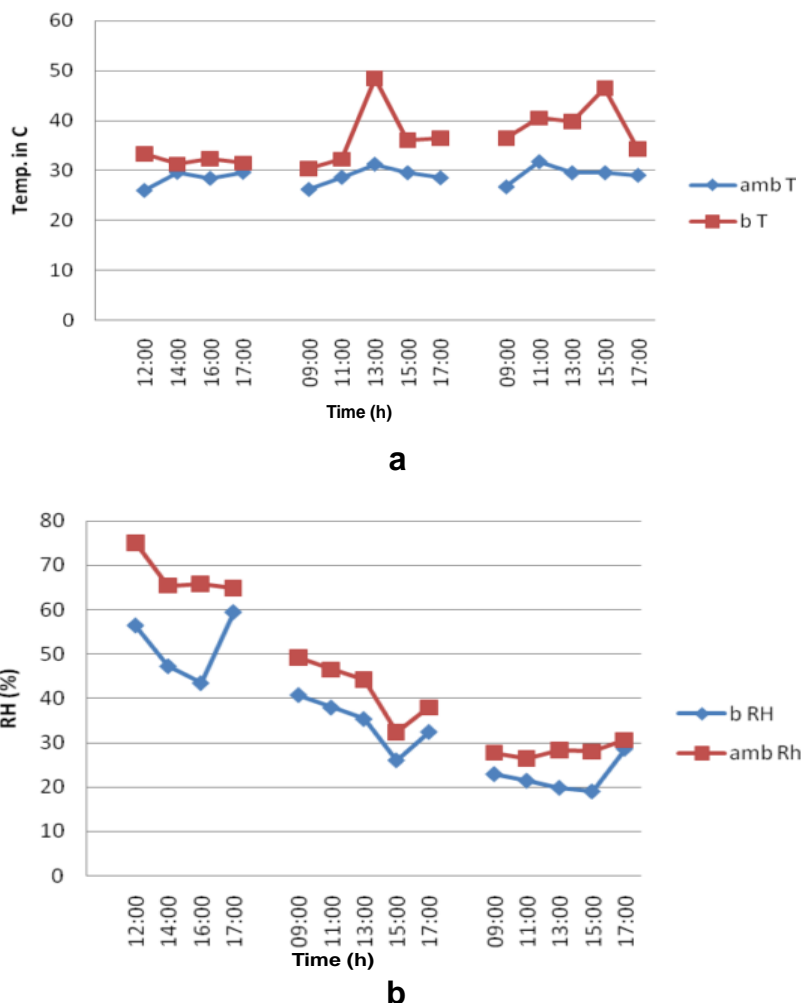
Figure 2 is the graphical representation of the hourly solar radiation and ambient temperatures of March, 17<sup>th</sup> to 21<sup>st</sup> 2010 which were the periods the study was done. In the graphs,  $T_a$  is the ambient temperature; the subscripts 1, 2, 3, 4, 5 represent 17<sup>th</sup>, 18<sup>th</sup>, 19<sup>th</sup>, 20<sup>th</sup> and 21<sup>st</sup> March, respectively;  $G$  is the solar radiation. The ambient temperature varies in sympathy with the solar radiation rising as the solar radiation reaches its peak. Then as the solar radiation decreases the ambient temperatures were still high till late evenings due to the cloudiness of the area which trapped the heat wave (Duffie and Beckman, 1991). It is observed that the hourly solar radiation is maximum between the hours of 12:00 and 14:00 when the sun is vertically overhead while lowest at early morning and late evening hours of the day, respectively.

The ambient and chamber temperatures throughout the duration of the process excluding night periods ranged between 26.6 to 31.7°C (ambient), and 30.3 to 48.5°C (solar dryer), with ambient temperature having the least values for all readings as shown in Figure 3a. The maximum relative humidity recorded were 88.5% (ambient), and 59.5% (solar dryer) with ambient relative humidity having the highest values for all readings as shown in Figure 3b.

At interval of one hour each sample was weighed and moisture content calculated from the weight loss. The average initial moisture content (wet basis) of the samples was 71.82% while the moisture content (wet basis) of the samples when they were dried were 43.63% (Garlic), 46.2% (Ginger) and 40.82% (Brine). The monthly average daily radiation for the month of November during which the study was done has been estimated to be 17.101 MJm<sup>-2</sup>day<sup>-1</sup> for Nsukka (Agbo and Ezema, 2008).

Based on the Newton model of thin layer drying and

**a****b****Figure 1.** (a) Solar dryer (b). Cross-section of the dryer.**Figure 2.** Graph of solar radiation and ambient temperature against time.



**Figure 3.** (a) Temperature (T) readings of the dryer and open-air system against time, (where b = dryer and amb = ambient). (b) Relative humidity (RH) of the dryer and open-air system against time.

observations by Kingsly et al. (2007) and Uluko et al. (2006) for material drying under varying relative humidity as in solar drying, the moisture ratio equation can be expressed as Equation 1, where MR is the moisture ratio (dimensionless),  $M_o$  is the initial moisture content (kg/kg, w.b), k is the drying rate constant (per day) and M = Moisture content dry basis (wb%) at the time t:

$$MR = \frac{M}{M_o} = e^{-kt} \quad (1)$$

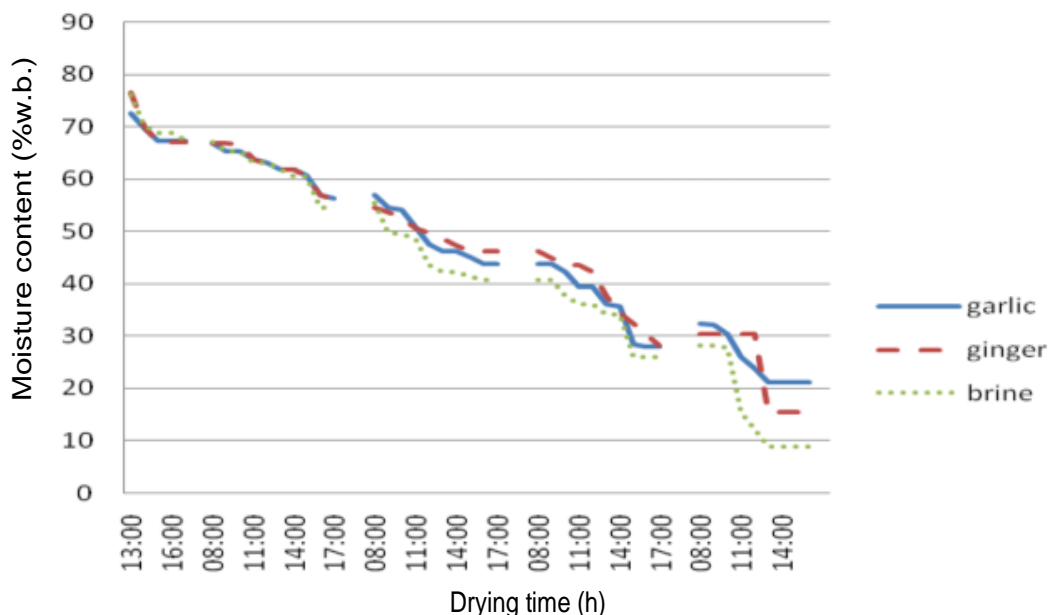
$$\ln\left(\frac{M}{M_o}\right) = -kt \quad (2)$$

$$M = \frac{\text{Initial weight} - \text{final weight}}{\text{final weight}} \times 100 \quad (3)$$

Figure 4 relates the moisture content of catfish with

drying time for different solutions (viz, brine, ginger, garlic). The figure shows that the drying process reduces with time. It is seen from the figure that within the first two days of drying that there was no significant difference among the moisture content for the solutions. However, from the third day the brined samples had the lowest moisture content for any given time.

Analysis of the graph  $\ln(M/M_o)$  against t (Appendix 1) indicates that the rate constant k (the slope of the graph) for the fish are 0.258 units per day (Garlic), 0.274 units per day (Ginger), 0.374 units per day (Brine). Using these values it is quite possible to link a given level of moisture content with a specified drying time. This could be achieved either graphically or analytically using Equation 2. It could be observed from the graph that only five days reading were used. This is because the fish for each drying method stopped losing significant moisture after the fifth day. Thus, only five days of drying were considered for achieving a linear slope. Furthermore,



**Figure 4.** Moisture content (%w.b.) vs drying time (hours).

straight line graph was used because the equation used for the plotting of the graph is a linear one. The results of correlation of  $\ln(M/M_0)$  ratio and time (t) are as follows: 0.959 (Garlic), 0.927 (Ginger), 0.895 (Brine). Since the coefficient of determination ( $R^2$ ) is high for all samples, there is a strong correlation between moisture ratio and time.

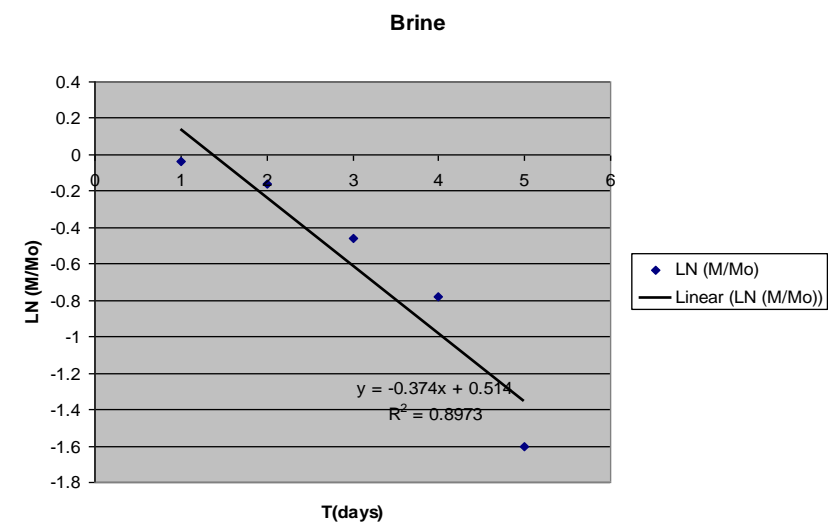
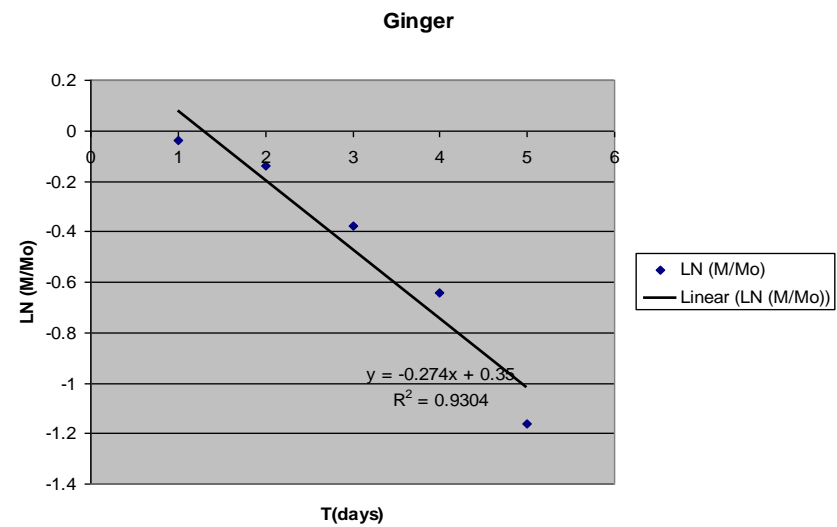
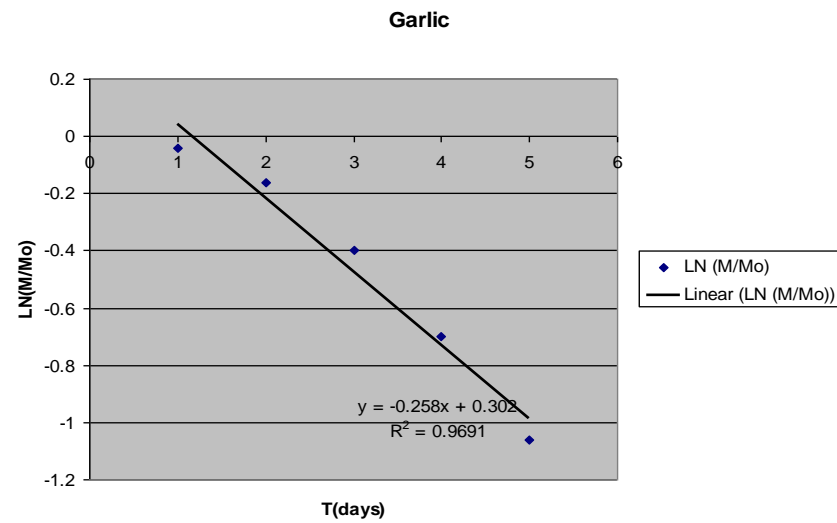
## Conclusion

Samples of cat fish were dried in the selected solar dryer. Initial moisture contents were measured before and after treating the samples with preservation solutions (brine, ginger and garlic solutions) while loss in mass was monitored every hour of drying. As a result of this, the rate constants for the sample under different conditions were successfully determined graphically (Appendix 1). The results obtained showed that cat fish dried using brine solution is the best since its drying rate constant has the highest value of 0.374 units per day followed by ginger (0.274 units per day) and then garlic solution (0.258 units per day) is the least. Thus, pickling of cat fish with ginger and garlic after brining to add flavour to the fish actually reduces the drying rate of the fish. Equally, Chukwu and Shaba (2009) in comparing two drying methods (electric oven and smoking) for drying catfish concluded that electric oven is better in terms of shelf life; however, considering the fact that in most developing countries electric power supply is quite unstable and costly the use of solar dryer has proven to be a more acceptable option.

## REFERENCES

- Agbo SN, Ezema FI (2008). Estimation of the monthly Average Daily Global Solar Radiation in Nsukka, Nigeria. *Nig. J. Solar Energy* 19(1):40-47.
- Choo PS, William MJ (2003). Fisheries Production in Asia: Its role in food security and nutrition. *NAGA, World Fish Center Quarterly*, 26(2):1-20.
- Chukwu O, Shaba IM (2009). Effects of Drying Methods on Proximate Compositions of Catfish (*Clarias gariepinus*). *World J. Agric. Sci.* 5(1):114-116.
- Delgado J, Martinez LM, Sanchez TT, Ramirez A, Iturria C, Gonzalez-Avila G (2005). Lung Cancer Pathogenesis Associated With Wood Smoke Exposure. *Chest* 128:124-131.
- Ekechukwu OV, Norton B (1999). Review of Solar Energy Systems: An Overview of Solar Drying Technology. *Energy Conver. Manage.* 40:615-655.
- Graivier N, Pinotti A, Califona A, Zaritzky N (2006). Diffusion of Sodium Chloride in Fork Tissue. *J. Food Eng.* 77(4):910-918.
- Kingsly RP, Goyal RK, Manikantau MR, Ilyas SM (2007). Effects of Pre-Treatments and Drying Air Temperature on Drying Behaviour of Peach Slices. *Int. J. Food Sci. Tech.* 42:65-69.
- Muthuveerappan VR, Ambalavanan G, Kunchithapatham M, Kamaraj G, Ananthanatesan T (1985). Low Cost Plastic Suction-type-greenhouse Grain Dryer. *Proc. ISES Conf, INTERSOL* 85:1077-1081.
- Ogunja JC, Werimo KO, Okemwe NF (1992). A case study of high-value Nile perch products. *Proceedings of the Symposium on post-harvest Fish Technology*. 41-45.
- Ojike O, Nwoke OO, Okonkwo WI (2009). Comparative Evaluation of Passive Solar Dryers using the Drying Rate Constants of Yellow Pepper and Okro as a Case Study. *Proc. Natl. Solar Energy Forum* 87-94.
- Oliviera IM, Fernandez FAN, Rodriguez S, Sousa PHM, Maia GA, Figueiredo RW (2006). Modelling and Optimisation of Osmotic Dehydration of Banana followed by Air Drying. *J. Food Eng.* 29:400-413.
- Orengoh P, Kisumo A (2007). "Kenya: Countries Fish Sector Poised for Boom", In *Proc.: East African Business Week*, 18th June 2007, Kampala, Uganda.

- Sadykov TA, Khairiddinov B (1982). A Year-round Double-block Greenhouse Dryer. Appl. Solar Energy, 18(1):69-72. Cited in Ekechukwu O. V. and Norton, B (1999).
- Shaw R (1981). Solar Drying Potatoes. Appropriate Technol. 7(4):26-27. Cited in Ekechukwu, O.V. and Norton, B. (1999).
- Shitanda D, Wanjala NV (2006). "Effect of Different Drying Methods on the Quality of Jute (*Corchorus Olitorius* L.)". Drying Technol. 24(1).
- Uluko H, Kanali CL, Mailutha JT, Shitanda D (2006). A Finite Element Model for the Analysis of Temperature and Moisture Distribution in a Solar Grain Dryer. Kenya J. Mech. Eng. 2(2):47-56.
- UNIFEM (1988). Fish Processing. United Nations Development Fund for Women, New York. P. 85.
- Whitefield DEV (2000). "Solar dryer systems and internet: important resources to improve food preparation", In Proc. at the International Conference on Solar Cooking; Kemberly, South Africa, between 26th-29th November, 2000.

**APPENDIX 1.** Graph Ln (M/M<sub>0</sub>) against time for different solutions used in the study.



*Full Length Research Paper*

# Performance of community based organizations in managing sustainable urban water supply and sanitation projects

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The advocacy of climatic change and ever increasing poverty has its impact on environmental degradation. Most of underdeveloped countries have experienced this impact through technical, economic, institutional and social constraints on water supply and sanitation infrastructures. The impact has much effect in urban areas (informal settlements) due to the nature of such settlements. Lack of a sustainable approach and an appropriate technology for the provision of water and sanitation has resulted in decreased coverage in terms of percentage of the population with access to safe water and adequate sanitation, thus necessitating the need for appropriate and sustainable water and sanitation systems. New strategies for water supply delivery, particularly the community participation has emerged and some Community Based Organizations (CBOs) have made a significant contribution to the development of community participation approaches. This paper analyses the effectiveness of community participation, appropriate technologies and the institutional arrangements for the overall performance. Tanzanian CBOs managing water supply and sanitation systems were studied. Results revealed that CBOs are effective in cost recovery as well as effective water and sanitation provision in low-income earners areas.

**Key words:** CBOs, community participation, environmental degradation, water supply and sanitation.

## INTRODUCTION

There is a direct linkage between livelihood and well being of human beings and water supply and sanitation services. Improved water supply and sanitation ultimately contribute towards nation building and prosperity by enhancing the health status of the common mass and thus, their economic productivity.

Despite significant progress recorded in the extension of basic water supply and sanitation services across the developing countries, climatic change and the ever increasing population and poverty has increased its impact on environmental degradation. Most of

undeveloped countries have experienced this impact through technical, economical, institutional and social constraints on water supply and sanitation infrastructures. The impact has much effect in urban areas (informal settlements) due to the nature of such settlements. Lack of a sustainable approach and an appropriate technology for the provision of water and sanitation has resulted in decreased coverage in terms of percentage of the population with access to safe water and adequate sanitation, thus necessitating the need for appropriate and sustainable water and sanitation systems. Moreover,

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the high rate of growth of urban populations in Africa and Tanzania in particular, has resulted partially from an increase in the number of urban households, brought about by changes in standards of living and attitudes towards dependence. The rate of growth in number of households across Africa averaged 3.1% between 1985 and 2000, and is set to continue at this rate until 2030 (Thompson et al., 2001). The consequent increase in demand for basic housing and services for urban populations, as well as skewed distribution of investment towards affluent suburban developments, has resulted in rapid expansion of unplanned and unserved settlements. Overcrowding exacerbates rate of transmission of infectious diseases, such as gastro-intestinal infections, and respiratory diseases such as tuberculosis, commonly associated with poor water quality, poor sanitation facilities, poor ventilation and air pollution (Esrey et al., 1990).

Population growth in Tanzanian urban areas has been increasing rapidly since 1960s. The 1978 and 1988 national census shows that a bigger share of urbanization results from rural-urban migration (Kaliba, 2002; Kessy, 2002). The resulting fast growth in population in urban areas increases pressures on resources to satisfy the increased demand for clean water and sanitation facilities. The increased demand for urban housing has been accompanied by inadequate planning enforcement that has resulted in increased informal settlements with inadequate water and sanitation services. Unsafe water and poor sanitation are the primary causes for the vast majority of water borne and primarily diarrhoeal diseases. Every year, unsafe water, coupled with lack of basic sanitation, kills at least 1.6 million children under the age of five years; more than eight times the number of peoples who died in the Asian tsunami of 2004 (WHO/UNESCO, 2006). Water borne diseases also inflict significant economic burden through the loss of productivity in the workforce and through increasing national health care costs. As a consequence of these pit falls, a billion people were locked in a cycle of poverty and disease (UNICEF/WHO, 2004).

This paper aims to address the effectiveness of community participation, appropriate technologies and institutional arrangements for the overall CBOs' performance in Tanzania. Through literature reviewed and case study, Tanzanian CBOs performance in managing sustainable urban water supply and sanitation projects was analyzed. The study was based on Hanna Nassif Community Development Association (HNCDA) in Dar Es Salaam, Tanzania (a Community Based Organization (CBO) Project).

## METHODOLOGY

The study was carried out through physical observations, documentary analysis, quantitative and qualitative methods. Data for the study was collected through a focused survey group of randomly selected CBOs practitioners and key stakeholders.

Interview/questionnaires supported with semi structured interview techniques were used to collect data. The interview with water kiosks operators and public water standpipe operators, water users who were found fetching water at water collection points and head of households were carried out to evaluate the satisfaction of the users and the performance of the CBOs. Findings from the 1994 and 1998 baseline survey studies were used as a basis for comparing the trend of water supply and sanitation services. The 1998 baseline study indicated that the number of registered households at Hanna Nassif settlement area were 1897. These registered households were used as a basis for selection of the households for the study. A total of 96 households (about 5.1% of the total registered households) were randomly selected for interview and physical observation of sanitation systems. In Hanna Nassif settlement area, there were 10 water kiosks and 20 public water standpipes. Interview was carried out with 8 water kiosks operators and 17 standpipes operators, HNCDA Secretary, 3 HNCDA Committee members, HNCDA treasurer, and 270 water users who were found fetching water at the water collection points. A total of 396 respondents were interviewed. Tables 1 and 2 summarize the interview/ questionnaires distribution patterns.

## Existing conditions of water supply and sanitation services

The problem of water and sanitation in urban and rural areas of developing countries including Tanzania is a major concern. The available water sources throughout the world are becoming depleted and this problem is aggravated by the rate at which populations are increasing, especially in developing countries. Currently, some 30 countries are considered to be water stressed, of which 20 are absolutely water scarce. It is predicted that by 2020, the number of water scarce countries will likely approach 35 (Rosegrant et al., 2002). It has been estimated that, one-third of the population of the developing world will face severe water shortage by 2025. Furthermore, the limited water resources as well as the lack of safe drinking water and sanitation are the most serious challenges of the twenty first century. Over 1 billion people lack access to clean water with nearly all of them living in developing countries. Yet, 2.6 billion people, 40% of the world population, half the developing world lack even a simple improved latrine (UNICEF/WHO, 2004; Elimelech, 2006).

## Water supply

According to Antonio (2005), more than 1.2 billion people in the world still lack access to safe drinking water. Barney (2005) noted that, over the next 30 years, virtually all of the world's population growth is expected to be concentrated in urban areas in the developing countries, with its attendant socio-economic and environmental impact. This portrays that developing countries are facing great challenges in meeting community water supply needs.

In Tanzania, increasing levels of poverty, population growth and lack of a sustainable housing policy mean that urban growth is often absorbed into informal settlements. These areas are characterized by lack of basic infrastructure like water (AFTU 1&2, 2002). Many urban residents cannot afford housing, and authorities themselves have few resources with which to improve or maintain infrastructure and services. Consequently housing, health, water quality and environmental conditions in the growing informal settlements of Tanzania's cities are extremely poor (Kessy, 2002).

The National Water Policy of Tanzania stipulates the need to have water resources with acceptable quality. Increased human activities including poor land use practices, as well as uncontrolled abstractions and pollution of water body impact on the quality and quantity of the available water (URT, 2002). Tanzania has a population of more than 38 million, with 25% of this population living in urban areas, while water supply extends to some 85% of the

**Table 1.** Interview/questionnaires distribution.

S/No	Category	Category population	Total respondents Interviewed
1	Kiosk Operators	10	8
2	Water standpipe Operators	20	17
3	HNCDA Committee members	4	3
4	HNCDA Treasurer	1	1
5	HNCDA Secretary	1	1
6	Head of Households (Hanna Nassif Registered houses)	1897	96
	Total	1933	126

**Table 2.** Interview distribution at water collection points.

Kiosk	Water collection point	Number of water collection points	Targeted number of interviewees	Total respondents interviewed
1	Kiosks	10	150	97
2	Public water standpipes	20	250	173
Total		30	300	270

urban population service is often poor and at best erratic. The urban poor do not receive adequate services although in some areas this situation is beginning to improve (UWSA, 2001).

The Tanzania urban water and sanitation sector like many similar institutions is undergoing decentralization. This process means a shift away from organizational structures where the district water engineer was responsible technically to the ministry but administratively to the local municipality, which in turn was responsible for managing cost recovery. Since 1994, a new scenario has emerged in Tanzania and now all the responsibility is devolved to the Urban Water and Sewerage Authorities (UWSA). With the support of legislation, the UWSA have significant autonomy linked to the achievement of key performance indicators.

The impact of decentralization is most apparent in the obligations of the Ministry of Water and the UWSAs. The traditional ministry role of 'provider of services' is now one of regulator of policy and facilitator of service expansion through fund allocation and UWSA performance monitoring. UWSAs is responsible for provision of services in quantity and quality standards required, set water and sewerage tariffs, collect revenue and plan and execute new projects for water supply. Table 3 shows the main source of drinking water for Tanzanian urban households in percentage. Table 3 reveals that few people have access to water supply (only 34.1% of the urban households is served by utility directly). Despite the many opportunities UWSAs face, many hurdles including the fact that not all customers pay their water bills, current supplies are intermittent, unaccounted for water (UFW) is in excess of 40% and leakage is also high (UWSA, 2001).

Typically, the urban poor are not seen as a viable customer base as the authority is pre-occupied by an attempt to recover costs for other market segments. Most of the poor segment in urban slum areas makes use of unsafe water for domestic purposes (UN-HABITAT, 2009). The water shortage drives most of the urban poor to fetch unsafe water for domestic use. Figure 1 shows the situation where most of urban poor fetch water for domestic purposes.

## Sanitation

In developing countries such as Tanzania, rapid population growth

and urbanization is creating an added demand for housing, infrastructure services including sanitation services. Providing sanitation services especially for the poor who are living outside the designated residential areas like illegal settlements or slums (informal settlements) is a challenge. The World Bank (2000) report estimates that almost 26% of the global urban population, over 400 million people, lack access to the simplest latrine.

Sanitation coverage in developing countries (49%) is only half that of the developed world (98%). In Sub-Saharan Africa, the coverage is a mere 36%, and over half of those are without improved sanitation. Similarly, nearly 1.5 billion people live in China and India without access to improved sanitation services (WHO/UNESCO, 2006). The number of deaths attributable to poor sanitation and hygiene alone may be as high as 1.6 million a year. Statistics on wastewater treatment reveal that almost 85% of global wastewater is discharged without treatment leading to serious impacts on public health and the receiving water environment.

The situation is even worse in areas of low-income settlements. Septic tanks and feeder networks regularly discharge effluent into street gutters, open streams or drainage canals. This creates unpleasant living conditions, public health risks and environmental damage (GHK, 2002). Sanitation coverage refers to the percentage of the population that has access to safe collection and disposal of wastewater. In the Southern Sahara countries, the coverage increased from 28% in 1980 to 36% in 1990. In 2003, the access to adequate excreta disposal was averaged to only 35% of the population. About 21.7% of the population had access to flush toilets, 66.8% to pit latrines and 11.6% use other options including open defecation (WHO, 2003). According to Ngware and Kironde (2000), only 6% of Dar-es Salaam's population has access to the choked sewers while 8% use septic tanks and 80% use pit latrines. Moreover, in informal settlements, the latrines are constructed in wrong locations due to lack of space. This situation has also been observed in Kinondoni Hanna Nassif Dar-es Salaam, Tanzania (Figure 2).

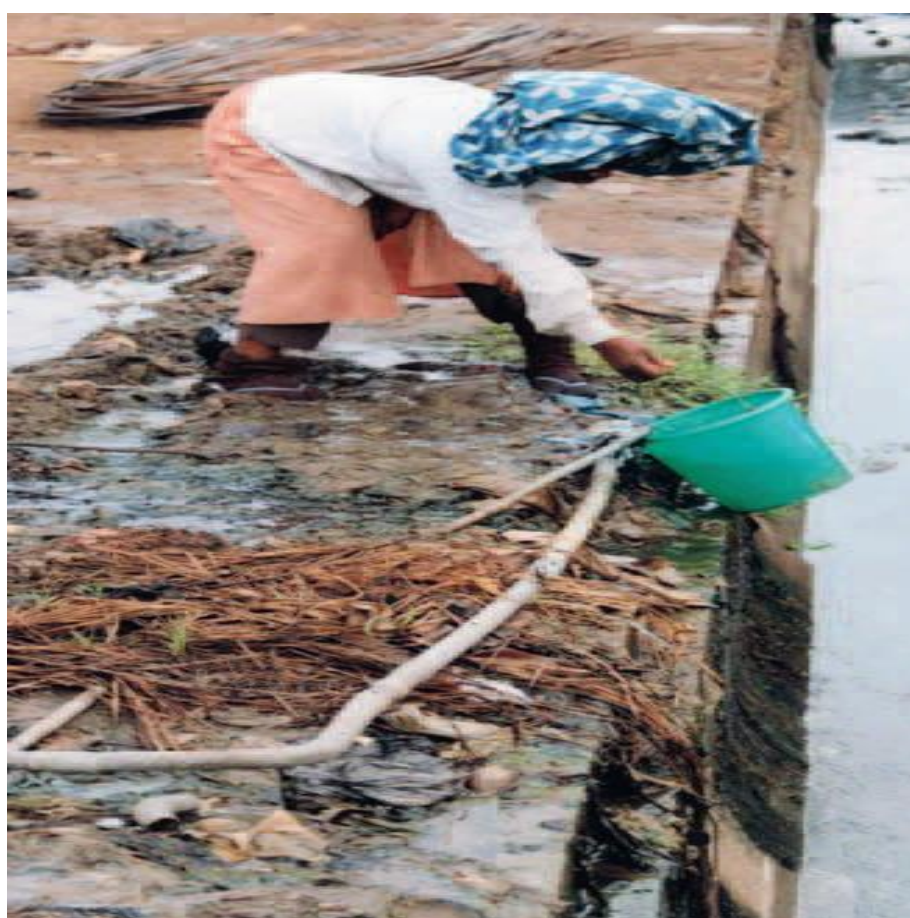
## Summary results of review of existing conditions of water supply and sanitation services in Tanzania

Despite many opportunities, Tanzania has a severe

**Table 3.** Main source of drinking water for Tanzanian urban households (% of households).

Source	Households (%)	Improved/ unimproved	Utility/ non-utility
Piped into dwelling/yard/plot	18.6	All improved sources: 77%	Households served by utility directly: 34.1%
Public tap	15.5		
Neighbour's tap	32.8		
Protected well / borehole	10.1		
Unprotected well / borehole	8.2		
Surface sources (river, lake, etc)	4.7	All unimproved sources: 23%	Households not served by utility: 65.9%
Vendor / tanker truck	7.2		
Springs	1.6		
Other	1.5		

Source: (TDHS, 2004).

**Figure 1.** A woman fetching water from a leaking pipe in a grubby area found at Bagamoyo town (a town near Dar es Salaam City). Source: UN-HABITAT (2009).

problem of safe water supply and access to improved sanitation services. Few people have access to water supply, with only 34.1% of the urban households being served by utility directly. Moreover, Tanzanian Urban Water and Sewerage Authorities (UWSAs) face many hurdles such as customers who do not pay their water

bills, current supplies are intermittent, unaccounted for Water (UFW) in excess of 40% and high leakage of water. Furthermore, in sanitation sector the situation in Tanzania is even worse than water supply. For example, a survey conducted in 1996 revealed that only 6% of Dar es Salaam's population has access to the choked sewers



**Figure 2.** In house latrines found in Kinondoni Hanna Nassif Dar es Salaam, Tanzania.

while 8% use septic tanks and 80% use pit latrines. However, the introduction of Community Based Organizations (CBOs) in Tanzania in upgrading informal settlements may improve the situation.

### **Performance of community based organizations (CBOS) in managing sustainable urban water supply and sanitation projects**

#### **Overview**

Historically, the performance of urban water and sanitation systems in developing countries including Tanzania remains below expectation. It should be recognized that urban water management poses extraordinary complex problems that cannot be solved by individual stakeholders. The failing of systems particularly in developing countries has been partly the result of a top-down approach with limited involvement of stakeholders (Khatri and Vairavamoorthy, 2007).

At the root of many failures is the lack of public participation, including participation of organized forms of the public such as CBOs and NGOs. Some would argue it is the 4<sup>th</sup> pillar of sustainable development. Participation is not happening due to governance failures as well as lack of awareness. People still do not understand the concept of sustainability and do not know how they can

contribute to its achievement. This leads to gaps and divergences in governments, CBO and NGO efforts to raise awareness among citizen groups.

Conventional wisdom dictates that without community participation, there is little likelihood of sustainability being realized (Narayan, 1995; Oyesiku, 1998). This is in part a pragmatic recognition of Governments' inability to deliver services, but in part an ideological proposition which values concepts such as 'empowerment', and 'capacity building' for their own sake. Even from a strictly practical approach, a number of the issues mentioned earlier illustrate the need for capacity building at the community level as well as at the level of Government or NGO, CBO.

Sustainability of facilities was reported by Overseas Development Institute (ODI) (2004), to be a major concern in the developing countries. Performance on sustainability is often gauged by looking at the number and proportion of functioning and non-functioning facilities. It also further noted that a functioning facility requires attention to a range of managerial, social, financial, institutional and technical issues.

In developing countries (including Tanzania), a significant number of projects, including those in the water and sanitation sector, fail to deliver benefits to society over the long term (Antonio, 2005). Part of the cause of this failure lies in poor understanding of the issues of impact and sustainability. Abrams (1998)



pointed out that, “if the water flows, then all of the many elements which are required for sustainability must have been in place. There must have been money for recurring expenses and for the occasional repair, there must have been acceptance from the consumers of the service, the source supplying the service must have been adequate, the design must have been properly done, and there must have been sound construction”.

To quote from the work of Abrams (1996) on the review of the African domestic water and sanitation: “It is generally agreed that community engagement and empowerment is the solution to the sustainability of water supply and sanitation services”. The hallmarks of empowerment and capacity building are factors such as transparency, partnership, flexibility, respect, and empathy.

Education in health and hygiene, training in maintenance and the handling of cash, and involvement of women in community institutions and decision making, are key activities needed to create local capacity to manage. On the part of Governments and NGOs/CBOs, listening and learning from the community, developing respect for existing methods of organization, problem solving, conflict resolution, and decision making, are essential components of such capacity building work. This calls for a fundamentally new approach to water, sanitation and human settlements whose aim is to satisfy the water needs while protecting the eco-systems.

Governments need to support and reinforce the efforts of the NGO/CBO community in this respect. This would lead to greater participation of the public to promote sustainable development at local levels. For example, in the United Kingdom, issues of sustainability are now being included in the school curriculums via for example, the sustainable Design Awards for 16-18 year olds and the sustainable Technology Education Project for 11-16 year olds. Such programmes should be encouraged, replicated and amply funded to raise awareness (UN, 2004).

Two different kinds of partnerships have been tried to increase effectiveness in poverty reduction, and sustainable development. The first is through working with the private sector, especially for urban infrastructure (including provision for water and sanitation) and in some cases housing finance. The second was working with the urban poor, including their community organizations and local NGOs. For extending and improving provision for water and sanitation, privatization proved disappointing; it did not succeed in bringing in large new sources of capital for investment from private markets (which had been one of the justifications for promoting it). Private companies were interested primarily in large cities with sizable middle classes rather than the smaller, poorer urban settlements where most of those without adequate provision actually live.

In Tanzania, CBOs and NGOs are observed currently participating fully in development and capacity building of urban and rural areas' projects, which central

Government and local Governments are embarking upon, particularly with assistance of UNICEF, IMF, World Bank and other international organizations financial supporters. CBOs and NGOs participation coupled with Governments and International supports appeared to be the right step at right time in the right direction in quest to ensuring better access to basic sanitation and safe drinking water.

### **Performance trend of the Dar-es- Salaam (DSM) water supply**

The government of Tanzania like any other developing country is unable to provide and maintain the most needed services to the urban community. This situation calls for more involvement and participation of the community aiming at stimulating the responsibility and willingness of community to operate and maintain their water systems. In DSM, the demand for clean water has in most cases outstripped the supply because the supply has been faced with inadequate and unreliable water sources. Other problems include unreliable power supply, dilapidated main water supply pipes from Lower Ruvu, and Upper Ruvu, characterized by leakages, problems of distribution systems, spaghetti of the subscribers' distribution pipes as well as illegal connections.

In 1984, the Tanzania government formed National Urban Water Authority (NUWA), in order to redress the problems of inadequate water supply throughout all urban areas in the country. NUWA was expected to start with DSM city and gradually extend its jurisdiction to all urban areas in the country. In 1997, the water demand in DSM was estimated to be 409,500 m<sup>3</sup> while the supply was 191,000 m<sup>3</sup> (Ngware and Kironde, 2000). Therefore, the supply was only 47% of the demand. It was then the same year the NUWA was transformed and renamed as DAWASA to operate in DSM, and was further given mandate to take over sewerage services in the city. In 2003, DAWASA was privatized to a foreign company- the Dar-es-Salaam City Water Company.

DAWASA was privatized by the Government of Tanzania so that to fulfill loan conditions of US\$98.76 million (that is, 164.6 billion Tanzanian Shillings (TZS), 1 Tanzanian shilling = 0.0006 US dollars) from the World Bank, International Development Agency (IDA), the African Development Bank (AfDB), and the European International Bank (EIB) for rehabilitation of water supply systems for the Dar-es-Salaam City, Kibaha Town and Bagamoyo (URT, 2004). It was expected that major rehabilitation of the water supply system of the city would be covered both in Lower and Upper Ruvu sources. Table 4 shows the water connection and distribution by City water in Kinondoni Municipal.

The Government of Tanzania expected the water supply service provision within the city to improve after the rehabilitation work, whereby leakages were expected to decrease from the 55 to 28% and revenue collection to

**Table 4.** Water connection and distribution by City Water in numbers at Kinondoni Municipal.

Domestic	Institutional	Commercial	Industrial	Total
5311	63	1056	6	6436

Source: (URT, 2004).

**Table 5.** Perceptions of trends in water supply over the last five years.

Indicator	Dar es Salaam (%)		Other urban (%)		Rural areas (%)		All areas (%)	
	I ↑	D ↓	I ↑	D ↓	I ↑	D ↓	I ↑	D ↓
Dry season shortages	20	33	27	26	20	29	21	29
Cleanliness	15	17	17	14	7	22	11	19
Queuing time	12	26	17	14	12	13	12	17
Cost	8	32	14	16	12	8	11	16
Distance	17	13	17	11	9	14	13	13

I ↑, Improved; D ↓, deteriorated. Source: Views of the People Survey (2007).

increase from 45 to 90% (URT, 2004). However, people perceived differently. Table 5 shows the perceptions of trends in water supply. The survey data indicators in Table 5 revealed that more efforts are needed to improve the water supply in urban as well as rural areas. However, results from the Jan et al. (1993) on developing, managing and maintaining community water supplies and sanitation projects suggests that water and sanitation targets can be achieved through empowering individuals, households, and communities to take charge of their development needs. Hence, full involvement of communities in all stages of project implementation and management is the correct pragmatic approach for the improvement of water supply delivery and sanitation services in urban as well as rural areas.

### **CASE STUDY: HANNA NASSIF COMMUNITY DEVELOPMENT ASSOCIATION (HNCDA)**

#### ***Evolution of the Hanna Nassif Community Development Association (HNCDA)***

Hanna Nassif ward is in Kinondoni Municipality Dar Es Salaam, Tanzania, with three sub-wards; Hanna Nassif, Mkunguni, and Kisutu. The upgraded area covers a part of the Hanna Nassif sub ward and another part of the Mkunguni sub ward. According to the 2002 census report, the upgraded settlements cover an area of 45 ha, with a population of twenty thousand (20000) people. The need for establishing a community based organization in Hanna Nassif settlement stemmed from the commonly felt problems, that is, flooding, poor road and drainage networks, inadequate water supply and sanitary services.

Hanna Nassif was earmarked for upgrading since the second phase of the National Sites and Services and Squatter Upgrading Programme phase II and III that

commenced in 1976 and 1981 respectively (Kessy, 2002). The programme was financially supported by the World Bank, but due to some reasons the efforts to upgrade Hanna Nassif could not succeed until 1991, when the move to improve basic infrastructure through community based approach was initiated by the community itself. This was a proper approach since community approach sought to empower local organizations and individuals through an atmosphere of dignity and participation, and an orientation to achieving durable results (O'Regan and Conway, 1993).

The primary objective of infrastructure improvement at Hanna Nassif was to improve the living environment by empowering the community to pioneer the development of basic infrastructure in collaboration with other stakeholders (Kessy, 2002). In recent years, many development agencies have focused on the promotion of participatory approaches to encourage bottom-up planning and empowerment of communities so that they take more control of development activities. It was under this effort that the Hanna Nassif community based infrastructure upgrading was promoted by the National Income Generation Programme (NIGP) (Salewi, 2004). This is in line with the National Water Policy on the issue of water for low-income groups and community user groups (the goal is to improve water and sanitation services in low income urban and peri-urban areas) (URT, 2002).

### **Performance trend of Hanna Nassif water supply and sanitation services**

#### ***Performance of water supply services***

**Water Supply Condition:** The Hanna Nassif water supply depends on the water main pipe through the



**Table 6.** Water supply connection in Hanna Nassif settlement.

Type of connection	1994 Total houses connection (%)	1998 Total houses connection (%)	Remarks
House connection	18.8	20	In house water network
Plot connection	39.4	8	Single tap
No water connection	41.8	72	Were buying water within settlement area

Source: UCLAS/ILO (1994; 1998).

settlement to Kinondoni area. The situation of water supply at Hanna Nassif settlement area is relatively better compared to the situation it was before the commencement of the project, out of 96 head of households interviewed, 85 (88.5%) head of households agreed that the project has reduced water shortage and improved drainage system. The same pattern of result was portrayed from the interview conducted with water users who were found fetching water at water collection points, out of 270 respondents, 246 (91.1%) respondents said that water shortage was reduced and drainage system was relatively improved. They pointed out that before commencement of the project pit latrines flooding was a major problem during rainy seasons. Construction of drainage system has reduced flooding problem. Moreover, the 1994 and 1998 trend of water supply was almost the same. Findings from the 1994 and 1998 baseline studies indicated that the Hanna Nassif settlement area did not experience frequent water shortages either from rationing or low pressure. The 1994 survey revealed that 63.3% of the total respondent households experienced a water shortage only once a month. The results from the 1998 survey revealed almost the same about 60% of the interviewed households experienced a water shortage within the same period. Moreover, findings of the 1994 and 1998 baseline studies showed that majority of the households get their water for domestic use from within the settlement. Furthermore, housing registration survey which was carried out on May 1998 revealed that out of 1897 houses, 20% (373) had private water connection, 8% (149) houses had plot connection and the remaining 72% (1375) had no water connection. People living in houses with no water connection were buying water within settlement area. Table 6 summarizes the water supply connection in Hanna Nassif settlement between 1994 and 1998.

**Water Consumption:** The HNCDA study indicated that water consumption within the Hanna Nassif settlement was gradually increasing. There was relatively small change of water consumption compared to the water consumption patterns revealed in the 1994 and 1998 baseline studies. The study showed that about 27% of the 396 total respondents interviewed were using less than 5 buckets per day or below 100 Lt per day, 46.2% between 101-200 Lt per day, 18.3% between 201-250 Lt

per day and the remaining 8.5%, were using above 250 Lt per day. Findings from the 1994 and 1998 baseline studies portrayed almost the same trend of water consumption. The 1994 survey study revealed that 47.9% of the sample population used below 100 Lt per day, 40.5% between 101-200 Lt per day, 7.2% between 201-250 Lt per day and 4.5% used above 250 Lt per day. The 1998 water consumption pattern indicated that 34% of the sample population was using below 100 Lt per day, 43% between 101-200 Lt per day, 15% between 201-250 Lt per day and the remaining 8% were using above 250 Lt per day. Table 7 shows water consumption pattern within the settlement between 1994 and 1998.

### **Performance of sanitation services**

The HNCDA study revealed that most of the houses in Hanna Nassif settlement area use pit latrines, out of 96 households which were visited, 79 (82.3%) households use pit latrines, 15 (15.6%) households use flush toilets and the remaining 2 (2.1%) households had no toilet facilities. Table 8 shows the summary of the observation results.

Moreover, results from the interview which was conducted with water users who were fetching water at water collection points reflected almost the same pattern; out of 270 respondents, 238 (88.2%) said that they use pit latrines, 29 (10.7%) said they use flush toilets and the remaining 3 (1.1%) respondents said that they had no toilets; however, they further pointed out that their toilets were demolished by flood. Table 9 summarizes the results of the interview conducted at the water collection points.

The 1998 baseline study showed that out of 1897 households that were registered, only 128 (6.7%) were using water closet and septic tanks sanitation system, 1758 (92.7%) had pit latrines and the remaining 11 (0.6%) had no toilets. Moreover, the 1998 baseline study revealed that one among the problems facing residents of Hanna Nassif was that of flooded latrines, about 11% of the sample households had been experiencing the problem. However, recent observations in the Hanna Nassif settlement revealed that this problem has been reduced as a result of improvement on the drainage system.

**Table 7.** Water consumption pattern.

<b>Amount of water consumption (L)</b>	<b>Year 1994 (%)</b>	<b>Year 1998 (%)</b>
Below 100	47.9	34
101-200	40.5	43
201-250	7.1	15
Above 250	4.5	8

Source: UCLAS/ILO (1994; 1998).

**Table 8.** Use of sanitation systems at Hanna Nassif settlement.

<b>Sanitation system</b>	<b>Number of households</b>	<b>Percentage</b>
Pit latrine	79	82.3
Closet	15	15.6
No Toilet	2	2.1
Total	96	100

**Table 9.** Summary of results of the interview conducted at water collection points.

<b>Type of sanitation system</b>	<b>Number of households</b>	<b>Percentage</b>
Pit latrine	238	88.2
Flash Toilet	29	10.7
No Toilet	3	1.1
Total	270	100

### Institutional arrangements

The source of the Hanna Nassif community water supply is from the City Water main distribution pipe along Kawawa Road. There are 10 public water kiosks, and 20 standpipes. The land on which the kiosks and the standpipes are installed was obtained from individual landlords. The landlords share the net revenue collected each month as partners in the service (that is, 50% of total collections less operational costs and the City Water bill).

The water supply serves the entire population of the Hanna Nassif sub ward and part of the Mkunguni sub ward. Many respondents of this study were satisfied by the service, but lamented that the HNCDA has raised the price of 20lt bucket dramatically from 0.006 to US\$0.012 (that is, 10/= to 20/= Tanzanian shillings (TZS.)). The respondents were comparing the price with those charged by some religious institutions at the area who own deep wells and sell water at a price of 0.006 US\$ (that is, 10/=TZS) per 20lt. bucket.

The distribution of water from the main pipes is not reliable due to leakages and the dilapidated condition of the pipes, which has forced the City Water Company to introduce an allocation system of supply to most of the city areas. The introduced water allocation system has

caused the community standpipes and some kiosks to remain dry in some days when the area is not supplied from the mains. The kiosks are installed with reservoir five tanks with capacity of 5,000lt, and the remaining five kiosks with tanks of 10,000lt capacity. However, this reserve cannot supply water to the community satisfactorily for a day, where as the allocation can sometimes extend for two or more days.

Since the Hanna Nassif Community water supply depends totally on the supply of the City Water Company, the performance of the Community Water Supply to a greater extent depends on the performance of the City Water. Therefore, the Institutional arrangement with the Community Water Supply Management to a greater extent influences the performance and the assurance of the sustainability of the service to the settlements. The government of Tanzania as in many developing countries is unable to provide and maintain the urban water supply systems. But since water and sanitation are critical components of development, the Central Government, Local governments, and Government Development Partners have a role to play in order to encourage and support the Communities, NGOs and CBOs in developing and maintaining water supply and Sanitation systems. This is critical especially in low-income urban communities.



**Figure 3.** A woman fetching water at a water kiosk.

### Performance of the actors

The performance of the actors in community-based water supply depends on the efficiency of the management team. The community participation in community based water services aims at stimulating the responsibility and willingness of community to operate and maintain their water and sanitation systems. They achieve this not only by training those involved in the day to day operations, but also by participatory planning to tailor services by organizing water committees to represent their community. The organization of water committee should focus on roles and responsibilities of the most affected, for example, the women and the poor, so that they would not be excluded from the use of the system and from decision-making. The HNCDA water committee has only 4 members that include two women. This committee is supposed to administer 20,000 people on water issues. More involvement of women especially in decision-making could help in the improvement of the service provision. Figure 3 shows a woman fetching water at a water kiosk.

### Accountability

The HNCDA's water supply service has three stages of accountability:

(a) Operators are answerable to the HNCDA water committee.

(b) The water committee is accountable to the executive committee.

(c) The executive committee is held accountable to the members of the HNCDA.

This set up needs frequent reporting of the progress from the operators up to the executive committee and from the committee to the general meeting. Apart from the reporting system, there is a need to have an organ within the system which is directly accountable to the users of the water. Lack of accountability to the users can lead to complaints that are detrimental to the overall performance of the water supply service. Financial accountability is also another issue of concern in Hanna Nassif community water supply. When interviewed, the secretary of the executive committee admitted that the HNCDA has no culture of frequent financial reports by the treasurer and/or the water committee to its members. The HNCDA constitution provides for annual financial reports in each general meeting. Frequent community meetings with an oral report given by the treasurer followed by questions and answers could help to minimize questions on financial accountability.

### Financial records and transparency

In Hanna Nassif, the kiosks and standpipes operators are not trained to manage financial recording and reporting. May be that is why the water points' financial records, are

not kept by the operators. All operators who were interviewed in this study said that they are only obliged to collect the daily sales at the water point, and send the sum to a selected member of the water committee, who in turn sends the money to the treasurer.

According to the operators interviewed in this study, daily collections per water point ranges from 1.2 to US\$3.00 (that is, 2,000/= TZS to 5,000/= TZS) for the kiosks while the sales at standpipe ranges from 1.2 to US\$1.8 (that is, 2,000/= TZS to 3,000/= TZS). Therefore this could be averaged to US\$63.00 (that is, 105,000/= TZS) per month per kiosk and US\$45.00 (that is, 75,000/= TZS) per month per standpipe. The interview with the HNCDA Treasurer showed that total sales per month is averaged at US\$36.00 (that is, 60,000/= TZS) per kiosk and US\$24.00 (that is, 40,000/= TZS) per standpipe per month. She said that the HNCDA pays US\$236.06 (that is, 393,440/= TZS) monthly bill to the City Water, and she averaged a balance of US\$90.00 (that is, 150,000/= TZS) as revenue after deducting all costs.

### Satisfaction of the users

Most of the customers interviewed were women found at the water points, who indicated satisfaction with the community water supply. They only lamented on the dramatic raise in price per 20lt. bucket. Responding on the question of the increase in price, the HNCDA secretary said the increase was due to the City Water Tariffs that are US\$0.00048 (that is, 80 cents TZS) per liter which amounts to US\$0.0096 (that is, 16 /= TZS) per 20lt. Before privatization of water distribution services, DAWASA was charging all community water supplies a subsidized price per liter, US\$0.00024 (that is, 40 cents TZS) per liter which amounted to US\$0.0048 (that is, 8/= TZS) per 20lt. And the HNCDA was selling at US\$0.006 (that is, 10/= TZS) per 20lt.

### CONCLUSION AND RECOMMENDATIONS

In recent years, many development agencies in developing countries including Tanzania have focused on the promotion of participatory approaches to encourage bottom-up planning and empowerment of communities so that they take more control of development activities, affecting their lives. Governments' inability largely due to lack of resources (financial) to maintain water and sanitation infrastructure has been the major factor contributing to the need for promotion of community participation in development programmes. Involvement of CBOs in managing water supply and sanitation projects provide an indirect economic impact. The socio-economic impact is attributed in the improvement of living standards of the society. The Hanna Nassif Community

Development Association (HNCDA) was meant for

infrastructure upgrading. The HNCDA study revealed that CBOs can contribute in improving water supply and sanitation systems, especially in informal settlements where most of households are low-income earners. However, there are numerous risks that threaten the sustainability of CBOs. These problems include; technical maintenance of the systems, management, cost recovery, planning, transparency in financial matters and in decision-making, as well as communications between committees and the community. Despite of these challenges, it has been revealed that full involvement of communities in all stages of project development, implementation and management lead to successful water supply and sanitation project success. Moreover, it is obvious that this approach does not divest Governments and NGOs of their responsibility for continuing and evolving support of the programmes which the communities promote. As communities change, and the needs of their water and sanitation systems change, the appropriate type of support (education, training, financial subsidy, technical assistance, maintenance, and even rehabilitation) should evolve. Continuous support to community participation and specifically institutional, legal, and contractual links between communities, Governments and NGOs should be developed.

### REFERENCES

- Abrams LJ (1996). Water Supply and Sanitation Development in Africa, Africa Sector Review-Report, UN Water Supply and Sanitation Collaborative Council, Working Group on Water Supply and Sanitation Development in Africa.
- Abrams LJ (1998). Understanding sustainability of local water services. Accessed from <http://www.thewaterpage.com/sustainability.htm> on January 2011.
- Antonio GF (2005). The European response to the challenges of Water and Sanitation in Developing Countries. In TRIBUNE, the document of European Commission.
- Barney C (2005). Urbanization in Developing Countries: Current trends, future Projection, and Key Challenges for Sustainability, J. Technol. Soc. 28:63-80.
- Elimelech M (2006). The Global Challenge for adequate and Safe Water, J. Water Supply, Res. Technol.-AQUA, 55(1):3-8.
- Esrey S, Potash JB, Robert SL, Shiff C (1990). Health benefits from improvements in water supply and sanitation, Survey and analysis of the literature on selected diseases. US Agency for International Development (USAID), Washington DC, USA, Water and Sanitation for Health (WASH) Technical /66/Rep.
- GHK (2002). Effective Strategic Planning for Urban Sanitation Services: Fundamentals of Good Practice, GHK Research and Training, UK. Accessed from <http://www.ghkeurope.com/products/prd02.asp?id=4> on March 2011.
- Jan D, Gerry G, Michad W (1993). Developing and Managing Community Water Supplies. Oxfam Publication Oxford UK, Oxfam Development Guidelines P. 8.
- Kaliba RM (2002). Participatory Evaluation of Community Based Water and Sanitation Programs: The Case of Central Tanzania. PhD Thesis, Department of Agricultural Economics, Kansas State University, Manhattan.
- Kessy AG (2002). Community Participation in Urban Infrastructure Provision, Research Series P. 33, Dortmund.
- Khatri KB, Vairavamoorthy K (2007). Challenges for Urban Water Supply and Sanitation in the Developing Countries: Discussion Draft

- Paper for the Session on Urbanisation, UNESCO, Delft, Netherlands.
- Narayan D (1995). The Contribution of People's Participation: Evidence from 121 Rural Water Supply Projects: Environmentally Sustainable Development Occasional Paper Series, No. 1, World Bank, Washington DC, USA.
- Ngware SSA and Kironde JML (2000). Urbanizing Tanzania: Issues, Initiatives, and Priorities, DUP (1996) Ltd, Dar es Salaam University Press, Tanzania.
- O'Regan F, Conway M (1993). From the bottom – up: Towards a strategy for Income and Employment Generation among the Disadvantaged, Aspen Institute, Washington DC, USA.
- Overseas Development Institute (ODI) (2004). From Plan to Action: Water Supply and Sanitation for the Poor in Africa.
- Oyesiku OO (1998). Modern Urban and Regional Planning Law and Administration in Nigeria, Kraft Books Limited, Ibadan.
- Rosegrant MW, Cai X, Cline SA (2002). Averting an Impending Crisis, Global water Outlook to 2025: Food Policy Report, International Water Management Institute (IWMI), Colombo, Sri Lanka.
- Salewi KW (2004). Poverty Alleviation through Infrastructure Provision and Development, NIGP, Dar es Salaam, Tanzania.
- TDHS (2004) Tanzania Demographic and Health Survey 2004/05.
- The World Bank AFTU 1&2 (2002). Country Assessment Report of Tanzania on: Upgrading Low Income Urban settlements.
- Thompson J, Porras IT, Tumwine JK, Mujwahuzi MR, Katui-Katua M, Johnstone N, Wood L (2001). Drawers of Water II: International Institute for Environment and Development, London, UK.
- UCLAS (1994). Baseline study, University College of Lands and Architectural Studies (UCLAS)/ILO, Tanzania.
- UCLAS (1998). Baseline study, University College of Lands and Architectural Studies (UCLAS)/ILO, Tanzania.
- UN (2004). Commission on Sustainable Development, Discussion papers submitted by major groups: Discussion paper on water, sanitation and human settlements submitted by non-governmental organizations, United Nations Economic and Social Council, Item 3 of the provisional agenda, Twelfth session 14-30 Apr. 2004. Accessed from <http://sdin-ngo.net/csd/pdf/csd12-discussionpaper-ngos.pdf> on November 2012.
- UN-HABITAT (2009). Tanzania: Bagamoyo Urban Sector Profile.
- UNESCO/WHO (2006). Meeting the MDG drinking Water and Sanitation target: The urban and rural challenge of the decade, United Nations Children's Fund and World Health Organization.
- UNICEF/WHO (2004). Meeting the MDG drinking Water and Sanitation target: A midterm assessment of progress, United Nations Children's Fund and World Health Organization.
- URT (2002). National Water Policy, United Republic of Tanzania.
- URT (2004). Water Supply Development report, United Republic of Tanzania, Kinondoni Municipal Council, Dar es Salaam, Tanzania.
- UWSA (2001). Draft Customer Services Guidelines, Urban Water and Sewerage Authorities, Tanzania.
- Views of the People (2007). Research and Analysis Working Group, United Republic of Tanzania. "Views of the People 2007: Tanzanians Give their Opinions on: Growth and Reduction of Income Poverty, Their Quality of Life and Social Well-being and Governance and Accountability." Dar es Salaam, Tanzania.
- WHO (2003). Water Supply and Sanitation Sector Monitoring Report, World Health Organization.
- World Bank (2000). Entering the 21st Century, World Development Report 1999/2000. Oxford University Press, New York.



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