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EVALUATION OF WATER TREATMENT PROBLEMS: CASE STUDY OF MAIDUGURI WATER TREATMENT PLANT (MWTP) AND MAIDUGURI ENVIRONS

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Abstract

Water remains the most useful universal solvent to human being and other animals, because of its derivative importance. However, effort to improve on raw water treatment would continue to be a subject of concern, because the process procedures are been violated or not properly upheld. This study was carried out in order to identify peculiar problems associate with water treatment at the Maiduguri Water Treatment Plant (MWTP). This research study was based on prompt time-schedules and plant site-visits, interviewed questions were made and accessing the technology adopted in the process stages. Analytical data were obtained through the use of sampling bottles, camera, record sheets and other necessary laboratory equipment. The analysis showed that treated water contained excess chlorine and aluminum with 1.10mg/l and 0.68mg/l respectively. From this study, the following are the root causes: poor facility lay out, poor organizational and functional structures, wear of pump impellers and surface deterioration in the transmission line, lack of calibration test, constant head system not operation properly, lack of jar test conduction, improper maintenance of filter system, and the use of chemical coagulant. Inferences were made at the end of the research to enhance process efficiency, healthier and more economical treatment MWTP.

Keywords: Evaluation, case-study, analysis, quality procedure, MWTP

1 Introduction

Water is an unusual compound with unique physical properties and as a result, it is the compound of life. It occupies about 67% or two-third (2/3) of the earth surface and in all folks of life (WHO, 2004). The many forms of water include: rain, snow, dam, oceans, lakes, rivers, streams and wells etc. Scientifically, it is found that the water in human bodies may not as apparent, but recognize that most of our weight is made of water. In fact, the normal adult is made up of approximately 60% of water. The human brain made up of 95% water, blood is 92% and lungs 90%. A 2% drop in our body's water supply can trigger signs of dehydration; fuzzy short-term memory, trouble with basic math, and difficulty focusing on smaller print, such as a computer screen (Sarojini 2008). Thus water is essential for life and without water no living creature would survive in few days.

Some of the many importance uses of water are: (i) serve as lubricants, (ii) regulate body temperatures, and (iii) removes harmful toxins from the body etc. Since water is such an important component to human physiology, it would be reasonable and healthy to maintain the right quality and quantity of water at all times.

Therefore, drinking water should always be clean and free of contamination to ensure proper health and wellness. The Maiduguri water treatment plant is a branch under State Ministry of Urban and Rural Development (MURD). The plant was designed purposely to treat water sourced from Alau Dam situated about 14km away, via underground pipe networking responsible for supplying portable drinking water to Maiduguri and its inhabitants.

1.1 Problem Statement

Water as the universal solvent, is essential to life. Many associated water-borne diseases such as polio, typhoid, cholera, hepatitis, shigellosis, salmonellosis and others can spread when the right

process procedures were not observed. These diseases cripple workers, ravage families and kill children which could affect the future of a nation. To assure a safe water supply for improving people's health, it is critical to monitor for the presence of these pathogens in the MWTP.

1.2 Justification of the Study

The study of peculiar problems associated with MWTP is of great importance for domestic and the development of industrial sector in Borno State. Since water is an essential requirement in life and most part of the Maiduguri metropolis depend solely on water supplied by the treatment plant, there is need to investigate the quality of drinking water and the constraint limiting the production of portable water by the plant today.

Therefore, the effort to evaluate the peculiarities of MWTP, proffers solutions and recommendations is the crux of this research study.

2 Background Literature

2.1 Sources of Water and its Impurities

The continuous movement of water between the earth and the atmosphere is a hydrological cycle. Water vapour from water and land surfaces and from living cells circulate through the atmosphere and falls as a rain or snow (Larry 1996). When it reaches the earth, water either flows into streams and then into oceans or lakes or it enters or infiltrates the soil. Some water becomes soil moisture, which may evaporate directly or move up through the roots of plants and be released by leaves. Some water percolate downward, accumulating in the so-called zone of saturation to form the ground water reservoir, the upper surface of which is the table water. Under normal conditions, the table water rises in response to inflowing water and then declines as water drains into natural outlets such as wells and springs (Larry 1996). Rain water is said to be purest among the various sources of water with about 0.0001% by solid impurities, but in an environment where the atmosphere is polluted by some hazardous gases e.g. carbon (ii) oxide (CO), carbon (iv) oxide (CO_2) etc., is not the purest. The amount of impurities in spring water and well are more than that of rain water but less compare to water from river and sea as reported by MWST (1999) and (Larry 1996).

2.2 Classification of Impurities

Impurities in raw water can be classified into three (3);

1. **Physical impurities:** These are solid particles which are present in raw water. They sometimes dissolve in water and give it color and turbidity, making it unpleasant for human consumption. These impurities may be in form of suspension, colloid or solution.
    a) Suspension – This is a stage in which the solid particles found in the running water can be seen with the naked eye. They float on water, the size of the particles vary depending on the velocity of the water. The higher the velocity, the smaller the particle and vice – versa Brown and Caldwell (2005), Abdulsalam et al., (2006).
    b) Colloid – This particle are finely divided into stages, most of the time may not be seen with the naked eye, but they have effect on the color of the water.
    c) Solution – These are soluble solids which are present in raw water. They cannot be seen but have impact on the color of the water (Larry 1996).
2. **Chemical impurities:** These are dissolved particles found their way into the water when rain washes away a farmland which had been sprayed with pesticides or fertilizer and also organic matter that had been dissolved by water. It affects the taste, color of the

water due to corrosion of pipes in transportation of water from the intake Brown and Caldwell (2005).

3. **Biological impurities:** These are impurities that occur as a result of micro-organisms found in raw water. These bacteria are harmful to humans. They can cause diseases known as water borne diseases (Larry 1996).

2.3 Classification of Water

(i) Ground water is the type of water that may be considered to be pure but may contain some organic and inorganic particles which will require addition treatment with chlorine for disinfection. Since the water is pure, it only requires little treatment. It originates in sub-terranean location such as wells etc., (Larry 1996), Abdulsalam et al., (2006).

(ii) Surface water is a type of water that is impure which contains traces of organic and inorganic impurities responsible for changing colour, odour, taste, pH and turbidity etc. The water requires a very thorough treatment processes for it to attain purity. This type of water can be found stream, river, lake, etc. (Larry 1996).

2.4 Minerals Found in Water

When the rain or snowing from the sky, the minerals content is nearly zero (that is, it contains no impurities). The minerals come from its contact with the soil. In areas with lots of limestone, the water will contain Ca and Mg. Likewise in areas with lots of granite and basalt, the water will contain Fe and Mg. Because the geology varies across the planet, the minerals found in the water and its concentration will vary as well. Ground water may have high concentration of some important minerals but be entirely devoid of other important minerals. Surface water, due to its limited contact with the ground, will have a much lower concentration of minerals. Not all minerals are considered healthful but may be found in the water as well. Lead and arsenic are examples of minerals that may be found in water yet are not healthful (Larry 1996), Brown and Caldwell (2005), Abdulsalam et al., (2006).

2.5 The Maiduguri Water Treatment Plant

The MWTP is a branch of Borno state water cooperation under Ministry of Urban and Rural Development, situated along Bama road, opposite University of Maiduguri. The plant treats surface water from Alau dam and was constructed by the metallurgical construction company of China (MCCC) and was commissioned in 1993. After all necessary tests were carried out; it was handed over to Borno State Water Corporation (BSWC) in the same year. Currently, the staff strength of MWTP is about 75 personnel of which 8 are non-professional. The department is responsible for supplying portable drinking water to Maiduguri and its inhabitants. The plant has a capacity of treating/purifying 67,000 m^3 of water on a daily basis. Unfortunately, only the people living in the surrounding project area are enjoying steady supply of portable water. However, most of those on the outskirts of Maiduguri get theirs from boreholes constructed by the state government.

The plant is operated under three (3) sections namely: (i) the administrative, (ii) the maintenance and (iii) the operation section.

2.6 Water Treatment Process

The steps used in treating raw water to make it safe and desirable for drinking vary widely between communities, due to the wide variability of raw water. The following procedure is

typical of a treatment plant processing raw water containing large amounts of impurities. For the case of Maiduguri water treatment plant that relies on a river as its water source. Such water vary

widely in amount and temperature from season to season, contain trace amounts of fertilizer from farm runoff and contain some treated wastewater from upstream communities and industries MWST (1999).

The purification of raw water may reduce the concentration of particulate matter including suspended particles, parasites bacteria, algae, viruses, fungi etc. The plant has many units which play different roles. The units work in a serial manner to produce potable water. These include: (i) the distribution chamber, (ii) aeration unit, (iii) clarification unit, (iv) filtration unit and (v) storage unit. Figure 1 depicts the process flow diagram of MWTP.

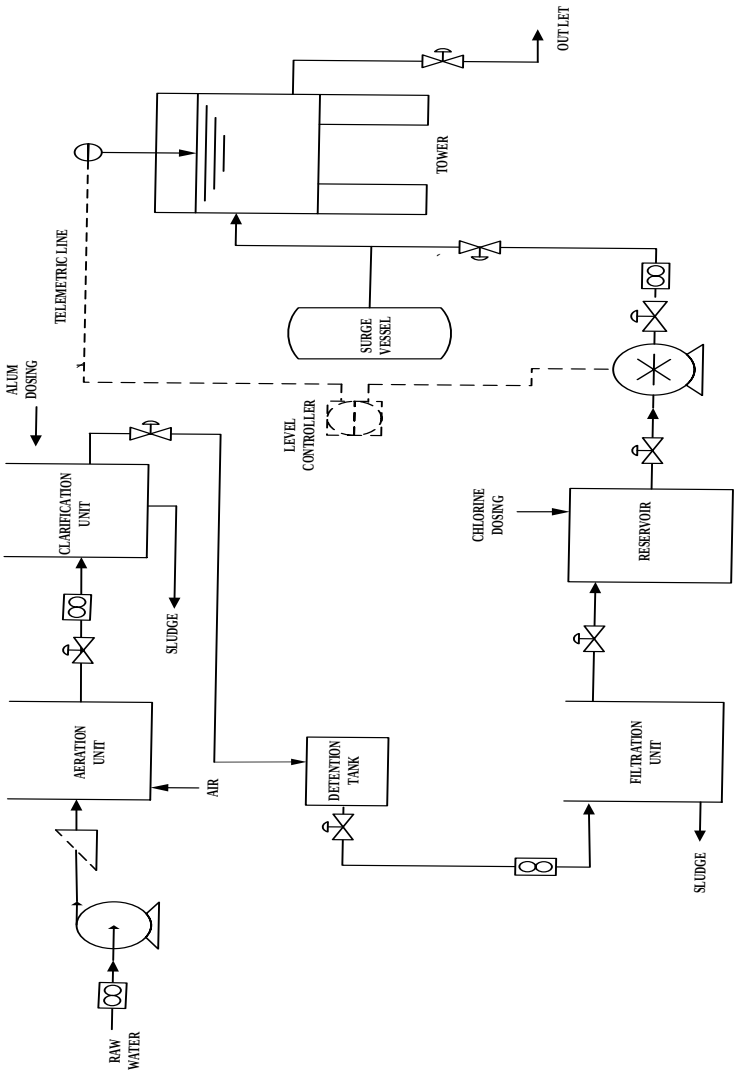

Figure 1: Process flow diagram of the MWTP Wakil (2014)

Figure 2 show the reservoirs of the intake water, while Figure 3 depicts the overhead storage tower of MWTP. While Figure 4 represents the high lift-centrifugal water pump and 5 Figure depicts the bar screen channel reservoir of the MWTP.

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Figure 2: Reservoirs, MWTP

Figure 3: Storage Tower of MWTP

Figure 4: High lift water pump, MWTP

Figure 5: Bar Screen channel, MWTP

3.0 Materials and Methods

3.1 Materials

The materials used include log-book and a digital camera for the collections of data. Also the MWTP manual and other relevant catalogues were consulted. In addition, relevant data were obtained from the process operations unit.

3.2 Methodology

This involved the visit to the MWTP sites, conduction of tests and discussions with the relevant staff and management, asking necessary questions that facilitate the accomplishment of the study of different stages of the treatment process. The machinery and technology used for the treatment process were also studied in order to ascertain the production capacity of the plant and make relevant recommendations of the latest and new technologies at the end of the study.

Water samples were obtained from each unit of the treatment plant and also within the metropolis from eight different locations for the qualitative analysis. The eight locations are:

1. Acada Area of the University of Maiduguri (A1).
2. Complex Area of the University of Maiduguri (A2).
3. Estate Housing: 202 Area, opposite the university (A3).
4. Estate Housing: 303 Area, opposite the university (A4).
5. Mairi: Zenith International School Area (A5).

6. Mairi: Bama Motor Park Area (A6).
7. New Government Residential Area (GRA): Nigerian Union of Journalist (NUJ) Area (A7).
8. New GRA: Unity Bank Area (A8).

Figure 6 represents the water samples collected from various locations in Maiduguri. While Figure 7(a) – (d) depicts some of the various equipments and instrumentation used in this research study.

New G.R.A samples:
A- NUJ line
B-Unity Bank area

Mairi samples:
A- Zenith school location
B- Bama motor park

Unimaid samples:
A- Acada
B- Complex

Estate Housing samples:
A- 303
B- 202

Figure 6: Water samples collected from various locations in Maiduguri.

(a) P_H meter (b) Multi parameter (c) Turbid meter (d) Test tube

Figure 7(a) – (d): Some of the various equipments and instrumentation used

4 EXPERIMENTAL RESULTS

4.1 Process Data Collected

The details of MWTP operations data collected were represented in Table 1.

Table 1: Summary of Maiduguri water treatment plant (MWTP)

S/No.	Parameters	Description.	Units
	Source of raw water	Alau Dam (Surface Water) built by Chad Basin Development Authority (CBDA)	
1.	Alau reservoir capacity	16750	m^3
2.	Intake works	Alau raw water pumping station (all flow is by gravity)	-
3.	Number of pumps	3 (2 on duty, 1 stand by)	-
4.	Flow per pump	540	l/s
5.	Motor	337	KWA
6.	Discharge pressure	55	m
7.	Normal power supply	PHCN	-
8.	Stand by power supply	2 generator sets; (i) 800 and (ii) 675	KVA
	Transmission line (raw water)		
9.	Pipe size (internal dia.)	800	mm
10.	Total pipe length (approx.)	12.5	km
11.	Plant inflow rate	1750	l/hr
12.	Plant output	67000	m^3/day
13.	Ground reservoir (65*65*4)	2 in number with each is 16750	m^3
14.	Number of overhead tank	(1000000gallons) each or 2, 4500	m^3
15.	Clarifier type	Flat bottom clarifier	-
16.	Treatment chemicals	Lime for pH adjustment, Aluminum sulfate (alum) for flocculation, Chlorine for disinfection, Ammonium sulfate for longer sterilization.	-
17.	Pump type (High lift pump)	1st set of pumping to system 1is 185 2nd set of pumping to system 2 is 132	KVA KVA
18.	Filter type	Rapid gravity sand filter	-

Table 2 gives a guide line to water quality parameters as set by World Health Organisation (WHO).

Table 2: Drinking water standards by WHO

Parameter	Guideline Value	Units
Final Water		
Colour Hazen	0-5	Pico
pH	6.5-8.5	
Turbidity	0-5	NTU
Free Cl_2	0.2-0.4	Mg/l
Aluminum	0-0.2	Mg/l
Conductivity	1500	µs/cm

Source: WHO 2004

Table 3 represent the data collected from the MWTP and it comprises of raw water, setter water, filtered water final water (for public consumption), using daily routine study analysis, the quality parametric data obtained for each location are presented in Tables 4 – 11 as below:

Table 3: Data collected from the MWTP

Parameters	Date of Taken Samples						UNITS
	30/04/13	07/05/13	14/05/13	21/06/13	28/06/13	04/06/13	
Raw Water							
Colour Hazen	144	132	107	123	156	101	Pico
pH	5.41	6.33	6.19	6.01	7.1	6.44	-
Turbidity NUT	11.66	14.16	10.13	19.36	21.54	14.66	NTU
Odour	-	-	-	-	-	-	Mg/l
Temperature	23	25	21	27	20	23	^{0}C
Setter Water							
Color Hazen	27	39	22	31	26	19	Pico
pH	7.03	7.13	7.04	6.73	7.31	7.01	-
Turbidity NUT	2.0	5.1	5.0	3.3	2.7	2.2	NTU
Aluminum mg/l	0.25	0.27	0.34	0.26	0.19	0.22	Mg/l
Filtered Water							
Color Hazen	4	11	9	3	4	5	Pico
pH	6.87	6.81	7.0	6.74	7.18	6.69	-
Turbidity NUT	2.65	2.5	4.6	2.05	2.61	1.55	NTU
Aluminum mg/l	0.31	0.33	0.52	0.51	0.74	0.23	Mg/l
Free Cl_2	0	0	0	0	0	0	Mg/l
Final Water							
Colour Hazen	0	2	0	0.3	0	0	Pico
pH	7.14	7.1	7.11	7.0	6.52	8.05	pH
Turbidity NUT	1.93	1.11	3.93	1.93	1.17	0.97	NTU
Free Cl_2 mg/l	1.6	0.6	0.58	1.7	0.79	1.50	Mg/l
Aluminum	0.27	0.71	1.17	0.61	0.49	1.12	Mg/l
Conductivity µs/cm	138	108	231	201	101	123	µs/cm

Table 4: University of Maiduguri Acada area

Parameter	Date of Taken Samples						UNITS
	30/04/13	07/05/13	14/05/13	21/06/13	28/06/13	04/06/13	
Final Water							
Colour Hazen	0	0	1	0	0	0	Pico
pH	7.14	7.1	7.11	7.0	6.59	8.05	-
Turbidity	1.18	4.00	3.18	2.00	2.20	0.97	NTU
Free Cl_2	1.57	0.48	0.57	1.50	0.80	1.54	Mg/l
Aluminum	0.25	0.61	1.07	0.51	0.50	1.10	Mg/l
Conductivity	145	140	142	124	147	118	µs/cm

Table 5: University of Maiduguri Complex area

Parameter	Date of Taken Samples						UNITS
	30/04/13	07/05/13	14/05/13	21/06/13	28/06/13	04/06/13	
Final Water							
Colour Hazen	0	0	0	0	4	1	Pico
pH	7.02	7.10	7.17	7.0	7.10	8.09	-
Turbidity	3.41	2.90	5.30	0.33	1.12	1.01	NTU
Free Cl_2	1.48	0.52	0.50	1.51	0.69	1.42	Mg/l
Aluminum	0.24	0.51	1.13	0.60	0.39	0.92	Mg/l
Conductivity	150	149	152	111	121	134	µs/cm

Table 6: 202 Estate Housing areas

Parameter	Date of Taken Samples						UNITS
	30/04/13	07/05/13	14/05/13	21/06/13	28/06/13	04/06/13	
Final Water							
Colour Hazen	0	0	2	0	0	1	Pico
pH	7.16	7.1	6.99	7.0	7.52	7.05	-
Turbidity	1.56	0.97	5.35	0.03	0.81	1.10	NTU
Free Cl_2	1.55	0.50	0.59	1.62	0.72	1.47	Mg/l
Aluminum	0.23	0.70	0.99	0.51	0.47	1.02	Mg/l
Conductivity	109	123	162	120	139	131	µs/cm

Table 7: 303 Estate Housing areas

Parameter	Date of Taken Samples						UNITS
	30/04/13	07/05/13	14/05/13	21/06/13	28/06/13	04/06/13	
Final Water							
Colour Hazen	0	2	0	0	0	0	Pico
pH	6.84	7.12	7.01	7.50	7.52	7.05	-
Turbidity	0.21	0.01	5.20	0.39	1.17	0.09	NTU
Free Cl_2	1.43	0.52	0.53	1.71	0.79	1.52	Mg/l
Aluminum	0.26	0.70	1.14	0.62	0.41	1.09	Mg/l
Conductivity	190	100	134	133	148	125	µs/cm

Table 8: Mairi: Zenith International School

Parameter	Date of Taken Samples						UNITS
	30/04/13	07/05/13	14/05/13	21/06/13	28/06/13	04/06/13	
Final Water							
Colour Hazen	0	0	0	0	0	0	Pico
pH	7.77	7.50	7.24	7.11	7.61	7.10	-
Turbidity	5.40	5.64	7.83	5.67	6.15	4.88	NTU
Free Cl_2	1.55	0.58	0.55	1.49	0.67	1.48	Mg/l
Aluminum	0.24	0.68	0.87	0.51	0.41	1.0	Mg/l
Conductivity	118	110	130	141	111	209	µs/cm

Table 9: Mairi: Bama Motor Park

Parameter	Date of Taken Samples						UNITS
	30/04/13	07/05/13	14/05/13	21/06/13	28/06/13	04/06/13	
Final Water							
Colour Hazen	0	0	0	0	2	0	Pico
pH	6.87	6.05	5.0	6.11	6.91	5.59	-
Turbidity	1.93	0.97	5.05	0.71	0.91	2.40	NTU
Free Cl_2	1.53	0.54	0.51	1.65	0.73	1.39	Mg/l
Aluminum	0.20	0.56	0.97	0.46	0.39	0.82	Mg/l
Conductivity	147	123	120	169	178	127	µs/cm

Table 10: New GRA of NUJ Line

Parameter	Date of Taken Samples						UNITS
	30/04/13	07/05/13	14/05/13	21/06/13	28/06/13	04/06/13	
Final Water							
Colour Hazen	1	0	0	0	0	0	Pico
pH	6.85	7.52	7.17	7.02	6.59	7.19	-
Turbidity	4.62	1.17	5.56	5.51	1.50	3.37	NTU
Free Cl_2	1.50	0.59	0.48	1.63	0.61	1.48	Mg/l
Aluminum	0.19	0.61	1.10	0.53	0.38	0.87	Mg/l
Conductivity	128	101	109	132	132	118	µs/cm

Table 11: New GRA of Unity Bank

Parameter	Date of Taken Samples						UNITS
	30/04/13	07/05/13	14/05/13	21/06/13	28/06/13	04/06/13	
Final Water							
Colour Hazen	0	4	0	0	3	0	Pico
pH	7.53	7.62	6.52	7.30	8.14	8.00	-
Turbidity	0.89	0.47	5.17	0.11	1.21	1.13	NTU
Free Cl_2	1.47	0.57	0.59	1.58	0.60	1.50	Mg/l
Aluminum	0.21	0.70	1.11	0.62	0.41	1.02	Mg/l
Conductivity	126	126	101	113	109	119	µs/cm

5. DISCUSSION OF RESULTS

The colour of the raw water to the treatment plant, MWTP (that is, Table 3) having a values in range of 144 – 101 Pico was very high when compared with the WHO standard (WHO 2004) as shown in Table 2,

having a values of 0 - 5 Pico. The final water is also acidic with the range values of 6.52 – 8.05 pH, and the turbidity is high too (10.13 - 21.54 NTU) when compared with WHO that is 0 – 5 NTU. The temperature was normal as the samples were usually taken in from the morning hours. This first analysis indicates that definitely the water must be treated before consumption because it is not aesthetically pleasing. In the second unit, it can be seen that the colour has drastically fall and the pH was adjusted to closely neutral. Also the turbidity has decreased which surely tells that the coagulation has taken place. A percentage of unreacted chemical (aluminum) are present that must be remove as shown in Table 3 (in range between 0.19 – 0.34 mg/l) after filtration, the colour haze drops yet did not reach the standard as given by WHO (in the range of 0 – 0.2 mg/l) as shown in Table 2. This is an indication that further processing must be carried out. The turbidity was found the same (0.97 – 3.93 NTU) which means the filtration is not satisfying and this was due to too much of the coagulant which re-stabilizes the colloid and improper backwashing. The aluminum content was shown high too because of the poor functioning of the dosing pump gradual accumulation of deposits of alum and reaction of chlorine with the walls of the storage tower over time. The final water shows the colour haze was good and the pH was adjusted to normal, that is 0 – 2 Pico and 6.53 – 8.05 pH respectively. More so, the free Cl_2 (0.58 – 1.50 mg/l) is very high when compared with the WHO (0.2 – 0.4 mg/l) standard. In addition, the aluminum (0.27 – 1.17 mg/l) in excess with respect to standards values from the WHO (0 – 0.2 mg/l). The excess of this free Cl_2 was due to the failure of the dosing pump which was off-scale equipment and therefore, the dosing was done manual by laborers (i.e. no accurate measurement). There is high tendency of negligence in this aspect. Table 3 represents the data collected from the MWTP (Ruth and Robin 2003).

From Table 4, the colour hazen was zero and the pH was also within standard range. The turbidity (0.97 – 4.00 NTU) was slightly above that of the final water (0.97 – 3.93 NTU) of the plant and this might be caused by pipe line leakages. While the pH for the Acada area was (6.59 – 8.05 pH) and the final water

from MWTP was (6.52 – 8.05 pH). The coagulant (118 – 147 μs/cm) and disinfectant (0.25 – 1.10 mg/l) are in excess with respect to standard (1500 μs/cm) and (0 – 0.2 mg/l) respectively. But fall within water treatment plant final water. This shows that the water is not portable for consumers at University of Maiduguri: Acada (A1), due to the presence of excess chemicals.

The result for University of Maiduguri: Complex (A2) in Table 5 shows that the parameters tested fall within the standard range except for the turbidity (0.97 – 3.93 NTU) which is slightly above that of the treated water (0.33 – 3.41 NTU) in the plant. Also the free Cl_2 and aluminum are seen to be within final water of the plant. This indicates that the consumers at this location are prone to water borne diseases.

Table 6 shows Estate Housing 202 (A3) results. The water is free of colour hazen and acidity as the pH was shown neutral (6.99 – 7.16 pH) in the table above. The turbidity was okay, yet the free Cl_2 (0.50 – 1.62 mg/l) and aluminum (0.23 – 1.02 mg/l) were found higher than standard but within water plant range which are respectively (0.2 – 0.3 mg/l) and (0 – 0.2 mg/l). This shows that the consumers are exposed to the dangers of these chemicals present in the water.

Table 7 shows the result for 303 Estate Housing (A4). The water was neutral as shown from the result and free of color too. The turbidity (0.01 – 5.20 NTU) mat be consider to be within standard range (0 – 5.0 NTU) but for the free Cl_2 and aluminum, they are in excess of WHO standard though less than the final water of the MWTP. This simply tells that consumers at this location are exposed to chemical hazards.

Mairi Zenith International School location (A5) results are shown in Table 8. The water was free from color and acidity. The turbidity (4.88 – 7.83 NTU) is slightly higher with respect to final treated water (0.97 – 3.03 NTU) of the plant and the free Cl_2 (0.55 – 1.55 mg/l) and aluminum (0.24 – 1.00 mg/l) are shown to be in excess as compared with WHO guide lines but falls within the range of the treated water of the MWTP. This indicates that the water is not highly safe for consumption.

For Mairi-Bama Motor Park (A6), Table 9 shows the analytical results of the water being consumed. The water is free of colour hazen but slightly acidic which may be as a result of domestic pipe lines that are made of metal reacted with the excess free Cl_2 to form acidic compounds. Also the free Cl_2 and aluminum are within final treated water of the MWTP. This water is not safe for the consumers because of the excess chemicals.

Table 10 is a test result for New G.R.A, NUJ location (A7). The water is free from color and acidity. The turbidity is slightly higher (1.17 – 5.56 NTU) than that of the treatment water (0.97 – 3.93 NTU) from the plant which indicating that there is a contamination along the distribution line. The free Cl_2 (0.48 – 1.63 mg/l) and aluminum (0.19 – 1.10 mg/l) are seen to be higher than WHO guide lines but within the range of final treated water of the plant.

Table 11 shows the result for Unity Bank location, New GRA (A8). The water is free of color and slightly basic. The turbidity shows normal for this location. The free Cl_2 and aluminum are found to be within the range of the final treated water of the MWTP.

Generally, these results can be demonstrated clearly by taking the averages of all the parameters for each location and tabulate as follows in Table 12.

Table 12: Average values of parameters for each location

Parameter	Treatment Plant	Unimaid		Estate Housing		Mairi		NEW GRA	
		Acada	Complex	202	303	Zenith School	Motor Park	NUJ Line	Unity Bank
Colour (Peco)	1	0.5	2	1	1	0	1	0.5	2
pH	7.28	7.32	7.54	7.25	7.17	7.43	6.85	7.05	7.33
Turbidity (NTU)	2.43	2.48	1.87	2.69	2.60	4.23	1.55	2.96	2.82
Free Cl_2 (mg/l)	1.1	1.02	1.0	1.06	1.15	1.05	1.08	0.98	1.07
Aluminum (mg/l)	0.68	0.67	0.68	0.62	0.7	0.55	0.58	0.64	0.68
Conductivity (μs/cm)	166	132.5	131	141	145	159.5	149	116.5	113.5

In summary, from Table 3, it can be clearly seen that for all the locations, the water is free from colour hazen with respect to WHO guide lines. The water is neutral at New G.R.A, NUJ (A7) line with pH 7.05

and slightly acidic at Mairi Bama Motor Park (A6). Mairi Zenith International School (A5) has the highest turbidity with 4.23 NTU even though it is within standard guide line range. The concentration of free Cl_2 and aluminum are shown to be high in all locations with respect to guide line standards. This clearly tells that the treatment process of the water plant was not sufficient to meet the required standard provided by the WHO.

Therefore, the causes to the unsafe water supply by the water plant are categorized under the following major problems, which are: poor facility lay out; improper maintenance; clarifier type used; selected filter media; coagulant used and system of operation. The resulting excess chemicals are causative agents for illness such as neurological diseases (e.g. pre-senile dementia or loss of memory) due to the presence of aluminium ions in dissolved form. Chlorine has been known to be poisonous and also leads to the formation of trihalomethanes (THMs) during chlorination of organic matter in water. It is also noted that, the sludge is discharged into downstream water (or river) which is very hazardous to human and public health in general because the sludge is not bio-degradable. This can also increase the acidity of the river water which is the major source of raw water Abdulsalam (2006).

In light of the above discussions, an improved process flow scheme is been proposed for the MWTP as shown in Figure 8 below. Some correlations were drawn in respect of this improvement from McCabe and Smith (2005).

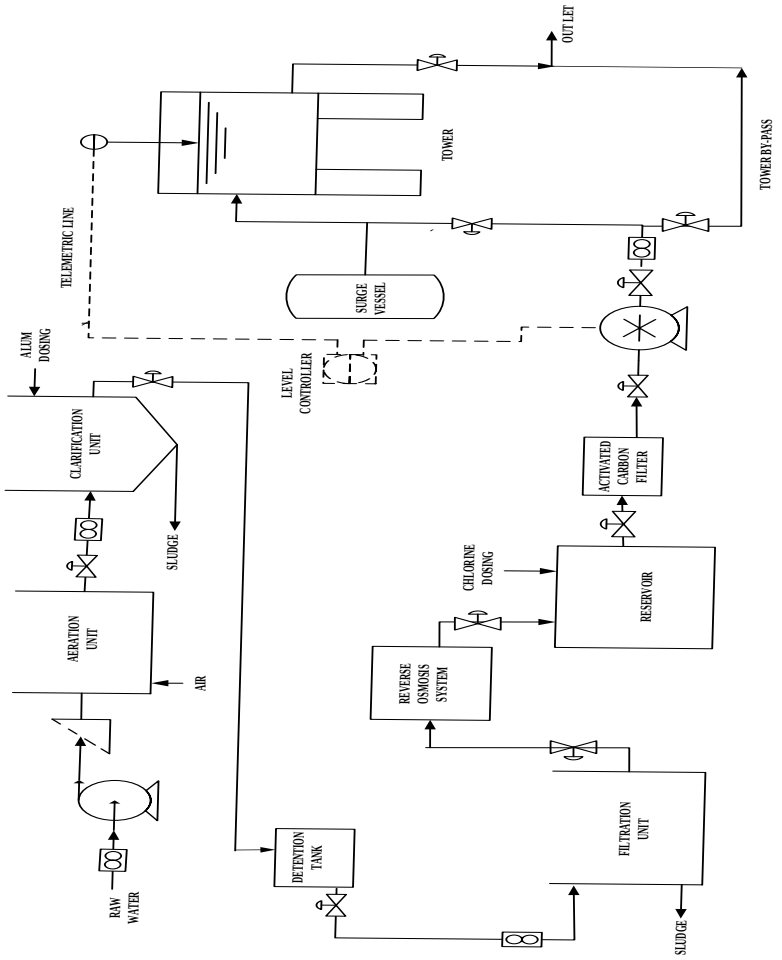

Figure 8: Proposed water treatment flow diagram for the MWTP

6 Conclusion

Within the limit of experimental error, the investigation on the overall performance of the MWTP plant was carried out. The results of the study reveal that the plant uses a semi-automatic absolute technology that is below what is currently obtainable and global standard.

Furthermore, the study also succeeded in analyzing the treatment process stages of the plant, the problem affecting the stages of the treatment and possible remedies to the problems identified. Base on the results it can be concluded that the areas receiving drinking water from the plant are exposed to some health hazards from excess chemicals present in the water. In addition regular monitoring of process units and distribution lines for any faults must be instituted and the proposed redesigning of distribution of the MWTP process by including of tower by-pass should be considered.

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