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Comparative Analysis of Three Groundwater Treatment Methods in Imo State Nigeria.

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ABSTRACT

In this study groundwater contaminants in Imo state made up of twenty-seven local government areas were investigated. Four (4) groundwater samples were collected from each local government area. This amounted to one hundred and eight (108) samples from the three senatorial zones of the state namely Owerri, Orlu and Okigwe. These samples were collected randomly from sites close to dump sites, septic tanks, Abattoirs, mechanic village, fertilized agricultural farms, industrial areas, clusters and from sites far away from perceived sources of contamination. To avoid contamination from tanks, the samples were collected at the well head, before water enters into tanks. Three (3) liters of water were collected from sample after pumping for about 3-5 minutes to ensure collection of representative samples. Well drained plastic containers tightly corked were used in collecting samples to minimize contamination that could alter the water constituents. The groundwater samples were tested for quality under physio-chemical and microbiological parameters using standard water quality methods. Water sample (1L) in the first container in each ground water was used for microbial test. The second container (1L) was acidified with two (2) drops of conc. HNO_3acid for cations determination in order to homogenize and prevent absorption and adsorption of metals to the wall of the plastic container. The third container (also 1L) was used for anion determination. These samples were preserved in boxes to keep the temperature below 20^oC and transferred to the laboratory for analysis within 24 hours of collection. Samples were analyzed for microbiological parameters like BOD, TVC and coliform. A three –in-one pH meter was used to determine the pH and total dissolved solids (TDS) of the water samples while conductivity meter was employed for the determination of electrical conductivity. Spectrophotometer was used in the determination of different hydrogeochemical parameters (sodium, potassium, chloride, nitrate and sulphate). Other analysis for magnesium and calcium were done by Complexometric titration method. Physical parameters namely pH, temperature, turbidity, total dissolved solids (TDS), hardness and electrical conductivity were determined for all samples. These results were used to ascertain the levels of groundwater contamination in Imo state. An equation was generated from the chemical parameters using SPSS and E-view softwares to estimate the maximum allowable distance for siting borehole from sources of contamination in Okigwe zone Imo state Nigeria.

The maximum allowable distance calculated for groundwater from sources of contamination is 15.81meters.

Keyword: Groundwater, Pollution, Contaminants and Waste

Introduction

The crucial role groundwater plays as a decentralized source of drinking water for millions rural and urban families cannot be overemphasized. The need to protect our groundwater from pollutants has become a great challenge in Imo state and Nigeria in general. It is a task that must be accomplished by all and sundry for sustainability of groundwater. There have been cases of groundwater pollution in Imo state reported by so many researchers. The type of pollutants depends on their various sources. Some may be wastes from hospital, septic tanks, acid rain, cemeteries, drycleaners, condemn batteries, chemicals/fertilizers, abattoirs, dumpsites, urban runoff, oil spillage, pesticides, food processing preservatives. Others include wastes from restaurants/hotels, pit latrine, cess pools, leachates, fuel station, herbicides, industrial wastes, agricultural waste and domestic wastes.
The rate of pollution depends on the concentration of these pollutants. Therefore groundwater is polluted when there are changes in the chemical, physical or biological quality of the water in such a way that it is detrimental for human or animal consumption and it is beyond acceptable limits by regulatory bodies like World Health Organisation (WHO) and Nigerian Standard Drinking Water Qualities (NSDWQ). The dangers of water pollution may include death of animals, water borne diseases like cholera, typhoid and hepatitis, skin thickening, neurological disorder, loss of appitite, cancer of the skin, bladder, kidney, lung and even muscular weakness.

Groundwater pollution is a serious problem in Imo state because of the indiscriminate way of dumping refuse. Virtually all streets, empty plots have one or more refuse dumps that are not wel constructed to handle waste. Little or no adequate waste management scheme was put in place. Nickson et al. (2005) established that approximately one- third of the world's population use groundwater for drinking, domestic and industrial purposes. An urgent need to protect this natural resource and sustain it for the next generation is a task that must be accomplished.

UNICEF (2007) stated that hundreds of people die every year from water borne diseases. The effects of groundwater pollution may change and depends on the kind of wastes dumped into the locations and can lead to destruction of ecosystem and shutting down economic activities. This is possible because hospital wastes and industrial waste contain toxins that threaten human health and creates dangerous issues for the environment.

Panouilleres et al (2007) observed that hospital wasteswater is.5 to15 times more toxic than typical urban outflows.

Once groundwater is contaminated, its quality cannot be restored by stopping the pollutants from source (Ramarkrishnaiah et al (2009).

It becomes imperative to regularly monitor the quality of different water bodies and device ways to perfect it (Yisa et al.,2010). So many treatment methods abound namely physical, biological and chemical treatment technologies.

For the physical treatment technology, we have

i) Pump and treat (ii) Air sparing (iii) Dual phase vacuum extraction (DPVE) (iv)monitoring well oil skimming

For biological treatment technology, we have

i) Bio-augumentation (ii) Bio-venting (iii) Bio- sparing (iv) Bio-sluring (v) phytoremediation

For chemical treatment technology, we have

i) Chemical precipitation (ii) Ion exchange (iii) Carbon absorption (iv) Chemical oxidation (v) Surfactant Enhanced Recovery (vi) Permeable Reactive Barrier.

No single treatment technology or method can give one hundred percent efficiency in removing pollutants found in groundwater (under all conditions). A combination of two or more treatment technologies may be helpful. Also old treatment methods like boiling, chlorination, filtration etc may no longer be effective to treat some pollutants.

Ragasulocham and Prealthy (2016) observed that these conventional treatment methods for removing groundwater contaminants are either becoming inadequate to meet current stringent regulatory effluents limit or are increasing in cost. Hence, the need for this study whose objective is comparative analysis of some groundwater treatment methods in Imo state Nigeria.

Review of Literature

Grohman(2002) observed that chlorine is a strong disinfectant that is effective at inactivating bacteria and viruses, and under certain circumstances, concentration and contact time inactivate vegetative bacteria. White (1999) showed that chlorine dioxide may be chosen because it has greater effectiveness against parasites. Disinfection is used to kill pathogenic micro-organisms in drinking water, rendering it safe to drink.

a) Chlorination Method

Chlorination is the most common water treatment methods because of its advantages over other treatment methods which include ease of administration, availability and time of treatment. Also chlorine residual remain in the water after the point of supply to respond to the challenge of post supply contamination. In essence, chlorine is more effective against bacteria and viruses (Ali, 2017) and least effective against certain protozoa. WHO recommends a minimum contact time of 15- using minutes and mg/l. The contact time value required for effective disinfectant is dependent on the combination of several factors, including

i) The concentration of chlorine in the water- more contact time needed for lower dosages
ii) The temperature of the water- more contact time needed for $<20^{o}C$ higher dosage for hotter temperature
iii) The PH of water-PH 5-8 is optimum, more contact time needed for PH>8.
iv) Turbidity of the water- more contact time needed for higher turbidity, but aim to always keep below 5NTU.

The process of removing some contaminants (microcystin) from water was ineffective (Hoffman, 1976; Keijola et al., 1988; and Himberg et al.1989). Although, they did not indicate the PH levels. Nicholson (1994) showed that at PH 8.5 efficiency of removal/destruction of contaminants was obtained. Nichson et al., (1994) showed that chorine and chloramines both destroyed microcystin pollutant at residual level of 0.5mg/dm^3 for 30 minutes contact time. The use of high dosage of chlorine is, therefore by itself not a guarantee of safe drinking water as the presence of reducing matter may result in high concentrations of disinfection by- products, such as trihalomethanes (THM), which are toxic (Hoff and Geldreich, 1981).

b) The 8-Step Filtration method

Various filtration processes are used in drinking water treatment. Used with proper design and operation, filtration can act as a consistent and effective barrier against microbial pathogens. Filtration is a physical removal of organisms together with other particulate matter.
Measurements of turbidity or particle counts, as well as determination of particle size distribution are excellent control parameters for this process (Gale et al, 1997).
If parallel filtration units are operated, it is essential that each unit is measured separately in order to ensure the recognition of poor performance in an individual filter unit.

The 8-step filtration system is made up of

i. Ceramic filter: The ceramic filter in the mineral water pot is made from a highly compressed ceramic diatomic substance, highly resistant to heat as tested by professionals. It is 0.2 microns in diameter much smaller than the diameter of bacteria, which is 0.5-10microns. It removes particles, sediments, rust, germs, bacteria, parameters etc. from your water.

ii. Activated carbon filter: This removes chlorine, organic chemical such as trihalomethanes. It also removes unpleasant odour, colour and taste and also leads from the water.

iii. Silica sand filter: This removes acidic compounds and water hardness, thereby softening the water. This brings the water to a pH balance.

iv. Zeolite filter: This absorbs heavy metals such as lead, mercury, copper, arsenic, cobalt, cadmium and chromium. Cu-zeolite removes nitrogen and organic substances. Silver-zeolite destroys any germs, bacteria or virus that may still remain in the water. Silver is used to prevent the growth of bacteria in the filter. This makes the water stay fresh long after filtration.

vi. Mineral sand (Beads) filter: This incorporates coral sand (Coral calcium), tourmaline (negative ions) to release minerals and adjust the pH of the water to a mild alkaline, which helps restore the pH balance within the body fluid.

vii. Bio ceramic beads filters: impregnated with silver emits far infrared rays (FIR) into the water. It also increases oxygen and minerals for our body needs.

vii. Mineral stones filter: This releases oxygen as well as various nourishing minerals such as potassium, sodium, calcium and magnesium and over twenty different ionized minerals, which are essential for good health into the water.

viii. Magnetic water tap: The earth's magnetic field, generally promotes vitality for the human body. To exploit this essence, the outlet tap of the water system is fitted with magnets in line with the latest water technology.

c) PRB Method

This involves the use of sand, gravel and zero valent iron set up like in slow sand filtration method and used to treat water.

Chemical Inactivation Chemical disinfection to inactivate pathogens is an important treatment barrier. Treatment effectiveness is a function of dose, contact time, temperature and sometimes pH. Primary disinfection is the process by which microorganisms are inactivated during the treatment process, which a secondary disinfectant can be added prior to distribution to maintain the water quality within the distribution system. Secondary disinfection provides a final barrier against bacterial contamination and re-growth within the distribution system. (USEPA, 1999).

Some treatment methods may not be functioning optimally. Sommer and Cabaj (1993) stressed the need to measure directly and know the ability of treatment processes to remove specific contaminants. Hunt and Marines (1999) showed that verification of the quality of water at the end of the treatment chain is necessary. There is also need to know the operating parameters and appropriate dosage. The use of high dosage of chlorine is, therefore, itself not a guarantee of safe drinking water as the presence of reducing matter may result in high concentration of disinfection by-products such as trihaloemthanes (THM), which are toxic. Water users in Imo state need to see at a glance the advantages and disadvantages of each groundwater treatment method, their efficiencies and cost effectiveness. The estimation of Chloride of the groundwater in Imo state has not been conducted, while there are several studies that estimate Chloride of the groundwater for various areas around the world (Joarder et al, 2008). This process is quite expensive and requires time to evaluate. To reduce cost of examination, therefore, the present study objectifies which include estimating the Chloride content of the groundwater in Imo through the multiple regression analysis is needful. In this study, the Pollution Index (PI) method will be used to estimate the efficiency of the treatment methods.

Materials and Methods

Four (4) groundwater samples were collected from four local government areas from each zone of the three zones that make up Imo state. This amounted to forty- eight (48) samples from the three senatorial zones of the state (Owerri, Orlu and Okigwe). These samples were collected randomly from sites close to dump sites, septic tanks, Abattoirs, mechanic village, fertilized agricultural farms, industrial areas, clusters and from sites far away from perceived sources of contamination. To avoid contamination from tanks, the samples were collected at the well head, before water enters into tanks. Three (3) liters of water was collected from sample after pumping for about 3-5 minutes to ensure collection of representative samples. Well drained plastic containers tightly corked were used in collecting samples to minimize contamination that could alter the water constituents.

The groundwater samples were tested for quality under physio-chemical and microbiological parameters using standard water quality methods described below;

Water sample (1L) in the first container in each ground water was used for microbial test.

The second container (1L) was acidified with two (2) drops of conc. HNO_3 acid for cations determination in order to homogenize and prevent absorption and adsorption of metals to the

wall of the plastic container. The third container (also 1L) was used for anion determination. These samples were preserved in boxes to keep the temperature below 20^{o}c and transferred to the laboratory for analysis within 24 hours of collection. Samples were analyzed for microbiological parameters like BOD, TVC and coliform) as described in Cheesbrough (2004).

A three –in-one pH meter was used to determine the pH and total dissolved solids (TDS) of the water samples while conductivity meter was employed for the determination of electrical conductivity. Spectrophotometer was used in the determination of different hydrogeochemical parameters (sodium, potassium, chloride, nitrate and sulphate). Other analyze for magnesium and calcium were done by Complexometric titration method as described in Cheesbrough (2004). All the containers used were rinsed asceptically with alcohol and distilled water.

Three (3) biological parameters namely biological oxygen demand (BOD), Total viable count (TVC) and Caliform unit were determined for each groundwater sample for each local government area and recorded.

Six (6) physical parameters namely pH, temperature, turbidity, total dissolved solids (TDS), hardness and electrical conductivity were determined for each groundwater sample for each local government area and recorded.

Ten (10) chemical parameters namely calcium, zinc, lead, iron, magnesium, sodium, sulphate, phosphate, chloride and nitrate were determined for each groundwater sample for each local government area and recorded. These results were used to ascertain the levels of groundwater contamination in Imo state.

The three methods were compared for efficiencies and results recorded.

Results and Discussion

The result for groundwater samples from different sources of contaminations and their distances were recorded in table 1 below for the twelve local governments. Table 2 represents the Biological parameters values of samples before treatment; Table 3 represents Biological parameters values of sample after the 3-Treatment methods. Table 4 showed Physical parameters values of sample before treatment, Table 5 showed physical parameters values of sample after PRB treatment, Table 6 showed Physical parameters values of sample after Chlorine treatment, Table 7 showed Physical parameters values of sample after 8-Step filtration treatment, Table 8 showed Comparison of results for the three treatment methods

Table 1: Borehole Water Samples and Their Distances from Possible Sources of Contamination.

LGA	Area	Distance from closet potential source of contamination (m)	Closest source of contamination.
ORSU	Orie Ama	30	Pit latrine
	Eke Umuhu 2	19	Pit latrine
	Nkwoama Miri	18	Septic tank
	Umuhu Okabia	18	Pit latrine
ISU	Umudike	21	Pit latrine
	Umuduru 2	24	Septic tank
	Umudu Ekwu	10	Open site
	Umuigbo	16	Pit latrine
ORU ESAT	Umuelala umuele	17	Septic tank
	Ihite Akatta	14	Pit latrine
	Ezioha Amagu	15	Refuse dump
	Ubahazu Amiri	13	Pit latrine
ORU WEST	Ezi Mgbidi	19	Septic tank
	Isi Mgbidi	21	Refuse dump
	Nnori Ububu	16	Pit latrine
	Umuokpara Anadi	15	Pit latrine
MBAITOLU	Ifakala	17	Pit latrine
	Ogwa	20	Septic tank
	Mberi	15	Septic tank
	Orodo	21	Pit latrine
EZINIHITTE MBAISE	Amakam Ezido	14	Septic tank
	Umuochaku	25	Pit latrine
	Umuotikpo Okpote	11	Pit latrine
	Umunagbor	22	Septic tank
ABOH MBAISE	Oboama Nguru	20	Refuse dump
	Umuanuma Nguru	30	Pit latrine
	Eziala Nguru	18	Septic tank
	Ezigaragu Enyiogugu	22	Pit latrine
Ngor Okala	Umuneli	24	Pit latrine
	Umuchoko	15	Pit latrine
	Umualum	21	Septic tank
	Umuafor	18	Septic tank
Ihitte Uboma	Isinwaeke	12	Pit latrine
	Amakohia	31	Pit latrine
	Umuihi	20	Septic tank
	Aboeke	33	Refuse dump
Okigwe	Ope	24	Septic tank
	Ubahaa	30	Refuse dump
	Umuka	20	Septic tank
	Umuokpara	18	Septic tank

Ehime Mbano	Umuezeala	28	Septic tank
	Umueze II	19	Septic tank
	Agbja	14	Pit latrine
	Umunakuru	28	Pit latrine
Isiala Mbano	Anara	31	Septic tank
	Amaraku	17	Refuse dump
	Ugiri	25	Pit latrine
	Umunkwo	20	Septic tank

Table 2: Biological Parameters Values of Samples before Treatment

	Sample Location	Parameters		
		BOD(mg/g)	TVC(Cfu/ml)	Coli Form(mg/l)
L.G.A	WHO // NSDQW standard	2.0	10	10
Orsu	Orie Ama	1.33	4.6 ± 0.04	4.0
	Eke Umuhu 2	1.24	5.8 ± 0.03	Nil
	Nkwogwa Miri	1.4	4.8 ± 0.02	Nil
	Nkwogwa Okabi	1.9	7.3 ± 0.01	5.0
Isu	Umudike	1.3	3.4 ± 0.05	Nil
	Umuduru 2	1.4	4.2 ± 0.06	Nil
	Umudu Ekwu	1.5	3.0 ± 0.07	Nil
	Umuigbo	1.2	5.0 ± 0.01	8.3
Oru-East	Umuelala	1.6	6.0 ± 0.02	Nil
	Ihite Akatta	1.55	7.1 ± 0.08	Nil
	Ezioha Amagu	1.65	8.1 ± 0.03	5.3
	Ubahazu Amiri	1.8	5.0 ± 0.01	Nil
Oru-West	Ezi Mgbidi	1.25	5.3 ± 0.04	Nil
	Isi Mgbidi	1.4	3.4 ± 0.06	Nil
	Nnori Ububu	1.6	4.1 ± 0.08	Nil
	Umuokpara	1.8	4.4 ± 0.07	4.1
Mbaitolu	Ifakala	1.9	6.0 ± 0.03	Nil
	Ogwa	2	4.3 ± 0.08	Nil
	Mberi	1.8	4.9 ± 0.01	Nil
	Orodo	1.2	5.2 ± 0.03	4.3
Ezinihitte	Amakam	1.2	6.4 ± 0.04	Nil
	Umuochaku	1.3	5.3 ± 0.06	Nil
	Umuotikpo	1.8	6.9 ± 0.06	Nil
	Umunagbor	1.6	7.1 ± 0.03	Nil
Abo-Mbaise	Oboama N	1.4	8.5 ± 0.07	Nil
	Unuanuma	2.2	8.5 ± 0.01	3.3
	Eziala Nguru	1.3	7.3 ± 0.02	Nil
	Enyiogugu	1.5	7.0 ± 0.03	Nil
Ngor-Okpala	Umuneli	1.2	4.8 ± 0.03	Nil
	Umuchoko	1.3	4.0 ± 0.01	Nil
	Umualum	1.4	5.6 ± 0.07	Nil
	Umuafor	1.4	3.8 ± 0.09	Nil
Ihitte Oboma	Isinwaeke	1.2	4.7 ± 0.06	Nil
	Amakohia	1.3	3.3 ± 0.04	Nil
	Umuihi	1.4	5.3 ± 0.02	Nil
	Aboeke	1.6	5.0 ± 0.03	Nil
Okigwe	Ope	1.7	3.7 ± 0.04	Nil

	Ubahaa	1.8	4.3 ± 0.07	7.4
	Umuka	1.5	4.7 ± 0.08	Nil
	Umuokpara	1.8	7.3 ± 0.08	Nil
Ehime	Umuezeala	1.3	5.3 ± 0.03	Nil
	Umueze II	1.4	4.3 ± 0.06	Nil
	Agbja	1.6	5.1 ± 0.08	Nil
	Umunakuru	1.7	4.7 ± 0.07	Nil
Isiala Mbano	Anara	1.8	3.8 ± 0.08	Nil
	Amaraku	1.5	4.9 ± 0.04	Nil
	Ugiri	1.8	8.2 ± 0.03	3.4
	Umunkwo	1.9	7.1 ± 0.01	Nil

Table 3: Biological Parameters Values of Sample after 3-Treatment methods

	Sample Location	BOD(Mg/l)			TVC (Cfu/ml)			Coil form (Mg/l)		
		PRB	CHL	STP	PRB	CHL	STP	PRB	CHL	STP
L.G.A	WHO/ NSDQW	2.0	2.0	2.0	10	10	10	10	10	10
Orsu	Orie Ama	1.4	1.8	1.7	2.6	6.2	3.9	2.5	3.4	3.6
	Eke Umuhu 2	1.2	1.6	1.6	3.8	5.2	5.1	Nil	Nil	Nil
	Nkwogwa	1.4	1.1	1.3	2.8	6.3	5.6	Nil	Nil	Nil
	Nkwo Okabi	1	1.2	1.5	3.3	4.3	3.9	1.5	3.3	4.0
Isu	Umudike	1.4	1.7	1.8	3.4	3.9	3.5	Nil	Nil	Nil
	Umuduru 2	1.2	1.8	1.9	4.2	5.1	5.5	Nil	Nil	Nil
	Umudu Ekwu	1.3	1.6	1.2	3.1	5.6	4.6	Nil	Nil	Nil
	Umuigbo	1.2	1.7	1.2	4.0	3.9	7.1	3.2	8.2	4.4
Oru-East	Umuelala	1.3	1.8	1.4	2.0	3.5	8.0	Nil	Nil	Nil
	Ihite Akatta	1.1	1.6	1.5	4.1	5.5	6.2	Nil	Nil	Nil
	Ezioha Amagu	1.5	1.1	1.4	3.1	4.6	5.4	4	4.3	4.3
	Ubahazu Ami	1.3	1.2	1.8	4.0	7.1	4.1	Nil	Nil	Nil
Oru-West	Ezi Mgbidi	1.4	1.7	1.7	2.3	8.0	2.4	Nil	Nil	Nil
	Isi Mgbidi	1.2	1.8	1.5	3.4	6.2	2.6	Nil	Nil	Nil
	Nnori Ububu	1.4	1.6	1.4	4.1	5.4	3.8	Nil	Nil	Nil
	Umuokpara	1.3	1.7	1.3	2.4	3.2	2.8	2.4	3.3	3.0
Mbaitolu	Ifakala	1.4	1.5	1.5	2.6	3.9	3.3	Nil	Nil	Nil
	Ogwa	1.2	1.4	1.7	3.8	5.1	3.4	Nil	Nil	Nil
	Mberi	1.3	1.8	1.6	2.8	5.6	4.2	Nil	Nil	Nil
	Orodo	1.4	1.6	1.9	3.3	3.9	3.1	2.1	3.8	3.2
Ezinihitte	Amakam	1.2	1.1	1.3	3.4	3.5	4.0	Nil	Nil	Nil
	Umuochaku	1.4	1.2	1.8	4.2	5.5	2.0	Nil	Nil	Nil
	Umuotikpo O	1.3	1.7	1.3	3.1	4.6	4.1	Nil	Nil	Nil
	Umunagbor	1.4	1.8	1.3	4.0	7.1	4.0	Nil	Nil	Nil
Abo-Mbaise	Oboama N	1.2	1.6	1.8	2.0	8.0	4.0	Nil	Nil	Nil
	Unuanuma	1	1.7	1.6	4.1	6.2	3.1	1.9	2.9	2.0
	Eziala Nguru	1.4	1.4	1.1	4.0	5.4	3.4	Nil	Nil	Nil
	Enyiogugu	1.2	1.5	1.2	4.0	4.1	4.1	Nil	Nil	Nil
Ngor-Okpala	Umuneli	1.4	1.3	1.7	3.1	2.4	2.4	Nil	Nil	Nil
	Umuchoko	1.3	1.5	1.8	3.4	2.6	3.4	Nil	Nil	Nil
	Umualum	1.4	1.8	1.6	4.1	3.8	6.2	Nil	Nil	Nil
	Umuafor	1.2	1.6	1.7	2.4	2.8	5.2	Nil	Nil	Nil
Ihitte	Isinwaeke	1.2	1.4	1.8	3.1	5.1	3.5	Nil	Nil	Nil
	Amakohia	1.2	1.5	1.6	4.0	5.6	6.3	Nil	Nil	Nil

	Umuihi	1.3	1.4	1.7	2.3	3.9	4.3	Nil	Nil	Nil
	Aboeke	1.8	1.8	1.4	3.4	3.5	3.9	Nil	Nil	Nil
Okigwe	Ope	1.6	1.7	1.5	4.1	5.5	5.1	Nil	Nil	Nil
	Ubahaa	1.4	1.5	1.3	2.4	4.6	5.6	4.5	5.5	5.0
	Umuka	1.2	1.4	1.5	4.0	7.1	3.9	Nil	Nil	Nil
	Umuokpara	1.2	1.3	1.8	2.3	8.0	3.5	Nil	Nil	Nil
Ehime	Umuezeala	1.2	1.8	1.7	3.4	6.3	5.6	Nil	Nil	Nil
	Umueze II	1.4	1.6	1.8	4.0	4.3	3.9	Nil	Nil	Nil
	Agbja	1.3	1.1	1.6	2.4	3.9	3.5	Nil	Nil	Nil
	Umunakuru	1.4	1.2	1.7	4.0	5.1	6.2	Nil	Nil	Nil
Isiala Mbano	Anara	1.2	1.7	1.4	2.3	5.6	5.2	Nil	Nil	Nil
	Amaraku	1.3	1.8	1.5	3.4	3.9	6.3	Nil	Nil	Nil
	Ugiri	1.4	1.6	1.3	4.1	3.5	4.3	1.9	2.9	2.6
	Umunkwo	1.7	1.7	1.5	2.4	5.5	3.9	Nil	Nil	Nil

Table 4: Physical Parameters Values of Sample before Treatment

L.G.A	Sample Location WHO/NSDQW	Parameters					
		PH 6.5-8.5	Temp ^{o}C	Turbidity 5.0	TDS (Mg/l) 500	Hardness 150	EC(Mg/l) 1000
Orsu	Orie Ama	6.3	28	5.2 + 0.4	87.0	44.2	98.0
	Eke Umuhu 2	5.9	27	6.4 + 0.3	65.0	31.6	118.5
	Nkwogwa Miri	5.8	26	7.0 + 0.5	76.2	36.2	93.7
	Nkwogwa Okabi	6.1	28	8.2 + 0.7	71.3	28.8	91.6
Isu	Umudike	6.2	29	6.7 + 0.2	80.3	32.6	112.8
	Umuduru 2	5.7	30	5.6 + 0.3	64.0	27.4	96.7
	Umudu Ekwu	6.4	28	6.5 + 0.4	58.6	31.6	115.5
	Umuigbo	5.8	27	8.1 + 0.3	81.9	36.1	102.6
Oru-East	Umuelala	6.5	28	4.4 + 0.4	90.7	24.8	89.9
	Ihite Akatta	5.4	29	3.8 + 0.3	82.0	36.4	98.4
	Ezioha Amagu	5.0	30	8.9 + 0.1	67.4	41.5	100.1
	Ubahazu Amiri	6.2	27	4.0 + 0.7	81.2	40.2	122.7
Oru-West	Ezi Mgbidi	6.4	26	6.6 + 0.2	66.1	37.5	88.9
	Isi Mgbidi	6.8	27	7.2 + 0.6	56.2	42.3	74.6
	Nnori Ububu	7.3	26	8.0 + 0.5	68.8	45.6	83.6
	Umuokpara	6.6	27	5.8 + 0.2	46.7	40.3	101.2
Mbaitolu	Ifakala	5.3	28	4.7 + 0.8	78.9	38.4	120.3
	Ogwa	6.1	29	5.1 + 0.6	66.5	20.4	100.7
	Mberi	6.9	28	6.2 + 0.5	79.1	30.3	90.6
	Orodo	5.8	29	7.2 + 0.6	62.4	28.3	98.7
Ezinihitte	Amakam	6.0	30	3.2 + 0.5	56.0	28.3	111.7
	Umuochaku	5.8	28	Nil	75.4	27.5	122.1
	Umuotikpo O	7.2	28	4.0 + 0.7	57.4	30.1	104.6
	Umunagbor	7.1	27	3.8 + 0.6	67.0	44.2	99.9
Aboh	Oboama N	6.8	27	5.7 + 0.7	57.5	31.6	103.8
	Unuanuma	6.0	28	4.9 + 0.6	48.0	36.2	98.4
	Eziala Nguru	6.4	29	37 + 0.6	61.3	28.8	117.6

	Ezigarag	5.4	30	3.9 + 0.9	70.2	32.6	94.6
Ngor-Okpala	Umuneli	5.8	27	8.5 + 0.6	63.3	27.4	97.6
	Umuchoko	5.2	27	7.4 + 0.4	58.9	31.6	95.8
	Umualum	6.6	28	3.5 + 0.2	59.3	36.1	89.7
	Umuafor	5.7	26	Nil	48.1	24.8	78.4
Ihitte	Isinwaeke	5.7	26	5.4 + 0.6	50.1	36.4	78.9
	Amakohia	6.1	30	3.7 + 0.4	68.3	41.5	92.4
	Umuihi	5.3	28	6.9 + 0.8	56.7	40.2	93.9
	Aboeke	6.8	27	7.1 + 0.1	50.6	37.5	122.8
Okigwe	Ope	5.3	30	8.4 + 0.7	80.3	42.3	102.5
	Ubahaa	6.1	31	9.1 + 0.7	72.3	45.6	95.6
	Umuka	6.7	29	8.2 + 0.6	60.2	40.3	74.8
	Umuokpara	5.0	29	6.3 + 0.5	30.8	38.4	80.1
Ehime	Umuezeala	5.8	30	8.2 + 0.2	32.4	36.2	116.0
	Umueze II	5.2	26	7.3 + 0.4	46.3	28.8	127.3
	Agbja	5.5	26	6.6 + 0.5	40.3	32.6	109.4
	Umunakuru	6.5	27	4.5 + 0.3	64.2	27.4	89.6
Isiala Mba	Anara	5.4	28	3.9 + 0.4	57.8	31.6	106.0
	Amaraku	6.1	29	6.1 + 0.7	69.9	36.1	130.0
	Ugiri	5.8	30	6.2 + 0.8	57.3	24.8	96.5
	Umunkwo	6.6	26	7.2 + 0.9	58.4	36.4	98.7

Table 5: Physical Parameters Values of Sample after PRB Treatment

LGA	Sample Location	Parameters					
	WHO/NSDWQ	PH 6.5-8.5	Temp oC	Turbidity 5.0	TDS (Mg/l) 500	Hardness 150	EC(Mg/l) 1000
ORSU	Orie Ama	7.4	26	3.0±0.1	10± 05	50.41	50.4
	Eke Um	8.0	27	4.2±0.3	12±0.4	45.3	45.3
	Nkwogwa	6.8	26	2.1±0.5	16±0.3	42.5	42.5
	Umuhu	6.6	18	2.3±0.5	14±0.2	42.5	42.5
ISU	Umudike	6.8	27	1.8±0.2	18±0.1	53.2	53.2
	Umuduru	7.3	29	2.0±0.4	11±0.3	37.1	37.1
	Umudu	7.1	30	1.3±0.6	13±0.6	48.9	48.9
	Umuigbo	8.4	28	1.5±0.1	10±0.4	61.7	61.7
Oru-East	Umuelala	8.6	26	2.3±0.5	11±0.7	32.6	32.6
	Ihite	6.4	26	1.1±0.7	15±0.3	28.7	28.7
	Ezioha	7.5	27	2.0±0.2	19.3±0.2	55.3	55.3
	Ubahazu	8.9	28	1.3±0.4	20±0.5	60.4	60.4
Oru West	Ezi Mgbidi	6.7	29	2.5±0.2	20±0.7	38.9	38.9
	Isi Mgbidi	6.3	27	3.0±0.1	21±0.8	24.5	24.5
	Nnori	7.6	28	3.2±0.3	22±0.7	28.1	28.1
	umuokpa	7.9	29	2.5±0.2	11±0.9	30.6	30.6
Mbaitolu	Ifakala	8.2	30	2.1±0.4	8±0.1	38.7	38.7
	Ogwa	8.7	26	1.8±0.3	14±0.2	43.4	43.4
	Mberi	6.4	28	1.9±0.3	10±0.4	52.3	52.3
	Orodo	6.9	29	2.4±0.4	17±0.3	63.9	63.9
Ezinihitt	Amakam	7.1	27	1.3±0.8	22±0.8	42.1	42.1
	umuochak	7.8	29	Nil	20±0.7	45.6	45.6
	Umuotikp	8.3	30	21.±0.4	19±0.6	51.7	51.7
	Umunagb	6.9	26	1.2±0.3	Nil	26.9	26.9

Aboh	Oboama	7.9	27	2.5±0.6	13±0.7	24.8	24.8
	Umuanum	8.2	27	2.1±0.7	25±0.6	18.3	18.3
	Eziala	7.4	28	2.0±0.1	21±0.1	24.8	24.8
	Ezigaragu	6.8	29	1.7±0.6	12±0.6	40.6	40.6
Ngor-Okp	umunell	6.7	29	2.1±0.2	18.9±0.2	41.6	41.6
	Umuchoko	6.4	28	3.0±4.0	13.6±0.7	37.8	37.8
	Umualum	8.5	27	1.2±0.1	11.4±0.4	44.2	44.2
	Umuafor	8.1	30	Nil	10.2±0.8	56.3	56.3
Ihitte	Isinwaeke	6.8	29	2.1±0.2	27±0.9	38.2	40.3
	Amakohia	7.4	30	1.1±0.3	18.0±0.6	42.7	38.2
	Umuihi	8.2	28	2.5±0.1	13.4±0.3	42.7	42.7
	Agboeke	6.3	30	3.0±0.4	30.1±0.4	27.6	42.7
Okigwe	Ope	7.9	27	1.3±0.6	39.1±0.2	38.4	27.6
	Ubahaa	6.5	26	1.8±0.7	28.5±0.5	42.9	38.4
	Umuka	6.7	29	2.0±0.4	22.4±0.6	39.7	42.9
	Umuokpar	8.4	26	3.2 ± 0.6	16.1±0.3	70.3	39.7
Ehime	Umuezeal	6.7	30	2.6±0.3	22.4±0.3	51.6	51.6
	Umueze 11	6.8	28	2.2±0.7	25.2±0.1	44.8	44.8
	Agbja	7.2	28	1.8±0.6	19.0±0.8	43	43.0
	Umunakur	8.4	27	5.0±0.3	13.3±0.2	37.6	37.6
Isiala	Anara	7.3	29	5.3±0.2	Nil	42.1	42.1
	Amaraku	8.7	28	1.8±0.3	10.4±0.7	38.7	38.7
	Ugiri	6.6	27	2.6±0.6	17.2±0.2	49.9	49.9
	Umunkwo	8.3	30	3.2±0.1	13.5±0.6	50.6	50.6

Table 6: Physical Parameters Values of Sample after Chlorine Treatment

LGA	Sample Location	Parameters					
	WHO/NSDWQ	PH 6.5-8.5	Temp °C	Turbidity 5.0	TDS (Mg/l) 500	Hardness 150	EC(Mg/l) 1000
Orsu	Orie Ama	6.4	28	.1+0.3	27.4	44.2	80.3
	Eke Umuhu 2	5.9	27	4.8+0.7	28.5	31.6	72.3
	Nkwogwa Miri	6.0	26	3.7 + 0.4	24.5	36.2	60.2
	Nkwogwa Okabi	6.3	28	5.2 + 0.5	30.7	28.8	60.8
Isu	Umudike	6.4	29	4.7 + 0.1	44.3	32.6	42.7
	Umuduru 2	5.9	30	5.0 + 0.2	50.7	27.4	80.4
	Umudu Ekwu	6.5	28	4.5 + 0.2	52.4	31.6	36.8
	Umuigbo	5.9	27	5.1 + 0.9	30.7	36.1	86.9
Oru-East	Umuelala	6.7	28	4.4 + 0.4	51.7	24.8	28.4
	Ihite Akatta	5.5	29	3.8 + 0.3	21.4	36.4	49.2
	Ezioha Amagu	5.3	30	4.9 + 0.1	29.8	41.5	53.7
	Ubahazu Amiri	6.4	27	4.0 + 0.7	32.7	40.2	50.4
Oru-West	Ezi Mgbidi	6.5	26	3.6 + 0.2	26.3	37.5	72.8
	Isi Mgbidi	6.8	27	5.2 + 0.6	57.0	42.3	60.5
	Nnori Ububu	7.5	26	5.0 + 0.5	57.2	45.6	42.6
	Umuokpara	6.7	27	4.8 + 0.2	51.9	40.3	74.8
Mbaitolu	Ifakala	5.4	28	4.7 + 0.8	60.3	38.4	80.1
	Ogwa	6.4	29	5.1 + 0.6	60.3	20.4	60.5

	Mberi	6.9	28	4.2 + 0.5	60.3	30.3	41.4
	Orodo	5.7	29	5.2 + 0.6	84.5	28.3	58.8
Ezinihitte	Amakam	6.2	30	3.2 + 0.5	81.4	24	44.6
	Umuochaku	5.9	28	Nil	40.5	27.3	56.1
	Umuotikpo O	7.2	28	4.0 + 0.7	45.0	30.1	62.6
	Umunagbor	7.4	27	3.8 + 0.6	42.3	44.2	49.7
Abo-Mbaise	Oboama N	6.7	27	5.7 + 0.7	80.3	31.6	61.2
	Unuanuma	6.2	28	4.9 + 0.6	38.0	36.2	53.4
	Eziala Nguru	6.4	29	37 + 0.6	26.7	28.8	67.6
	Ezigarag	5.5	30	3.9 + 0.9	40.7	32.6	44.6
Ngor-Okpala	Umuneli	5.7	27	4.5 + 0.6	38.1	27.4	77.6
	Umuchoko	5.6	27	4.4 + 0.4	31.7	31.6	55.8
	Umualum	6.4	28	3.5 + 0.2	34.2	36.1	69.7
	Umuafor	5.5	26	Nil	41.1	24.8	48.4
Ihitte	Isinwaeke	5.8	26	5.4 + 0.6	50.1	36.4	58.9
	Amakohia	6.0	30	3.7 + 0.4	18.3	41.5	62.4
	Umuihi	5.4	28	6.9 + 0.8	26.7	40.2	53.9
	Aboeke	6.6	27	5.1 + 0.1	Nil	37.5	52.8
Okigwe	Ope	5.4	30	6.4 + 0.4	80.3	42.3	62.5
	Ubahaa	6.3	31	5.1 + 0.3	72.3	45.6	75.6
	Umuka	6.7	29	5.4+ 0.5	60.2	40.3	74.8
	Umuokpara	5.3	29	4.3 + 0.2	30.8	38.4	80.1
Ehime	Umuezeala	5.8	30	6.2 + 0.2	28.4	36.2	66.0
	Umueze II	5.4	26	7.1 + 0.4	49.2	28.8	47.3
	Agbja	5.7	26	6.6 + 0.5	53.7	32.6	69.4
	Umunakuru	6.7	27	4.5 + 0.3	50.4	27.4	79.6
Isiala Mbano	Anara	5.5	28	3.9 + 0.4	18.9	31.6	84.2
	Amaraku	6.0	29	6.1 + 0.7	27.7	36.1	70.4.
	Ugiri	5.9	30	6.2 + 0.8	29.0	24.8	56.5
	Umunkwo	6.7	26	5.9 + 0.9	30.4	36.4	68.7

Table 7: Physical Parameters Values of Sample after 8-Step filtration Treatment

LGA	Sample Location	Parameters					
	WHO/NSDWQ	PH 6.5-8.5	Temp ^{o}C	Turbidity 5.0	TDS (Mg/l) 500	Hardness 150	EC(Mg/l) 1000
Orsu	Orie Ama	7.0	28	5.4+ 0.5	45.6	36.3	57.0
	Eke Umuhu 2	6.5	27	4.3 + 0.2	51.7	27.4	57.2
	Nkwogwa Miri	6.0	26	3.7 + 0.1	26.9	31.0	51.9
	Nkwogwa Okabi	6.4	28	3.1 + 0.7	24.8	28.4	60.3
Isu	Umudike	6.5	29	4.6 + 0.5	18.3	33.5	60.3
	Umuduru 2	6.2	30	5.1 + 0.1	24.8	24.6	60.3
	Umudu Ekwu	6.6	28	4.7 + 0.2	40.6	38.5	84.5
	Umuigbo	5.9	27	Nil	41.6	37.8	81.4
Oru-East	Umuelala	6.6	28	2.8 + 0.3	37.8	34.6	40.5
	Ihite Akatta	5.9	29	3.3 + 0.1	44.2	33.6	45.0
	Ezioha Amagu	5.2	30	4.5 + 0.8	56.3	40.0	42.3
	Ubahazu Amiri	6.1	27	6.2 + 0.7	36.7	44.2	80.3

Oru-West	Ezi Mgbidi	6.5	26	7.2 + 0.5	34.9	31.6	38.0
	Isi Mgbidi	6.9	27	6.0 + 0.6	41.0	36.2	26.7
	Nnori Ububu	7.5	26	3.8 + 0.1	39.7	28.8	40.7
	Umuokpara	6.7	27	4.0 + 0.3	45.8	32.6	38.1
Mbaitolu	Ifakala	5.4	28	6.7 + 0.2	45.8	27.4	31.7
	Ogwa	6.4	29	5.5 + 0.7	38.4	31.6	34.2
	Mberi	6.8	28	4.6 + 0.6	50.4	36.1	41.1
	Orodo	5.9	29	5.4 + 0.4	49.3	24.8	34.3
Ezinihitte	Amakam	6.0	30	6.7 + 0.8	34.6	36.4	44.5
	Umuochaku	5.6	28	5.0 + 0.2	40.9	41.5	42.1
	Umuotikpo O	7.5	28	4.8 + 0.7	60.3	40.2	40.0
	Umunagbor	7.4	27	6.3 + 0.3	50.7	37.5	50.1
Aboh	Oboama N	6.9	27	6.5 + 0.5	48.1	42.3	48.3
	Unuanuma	6.2	28	4.3 + 0.7	43.7	45.6	36.7
	Eziala Nguru	6.6	29	6.0 + 0.2	38.9	40.3	40.2
	Ezigarag	5.7	30	3.5 + 0.3	51.6	38.4	80.3
Ngor okpala	Umuneli	6.0	27	Nil	44.8	20.4	72.3
	Umuchoko	5.6	27	4.4 + 0.6	43.0	30.3	60.2
	Umualum	6.7	28	3.9 + 0.8	37.6	28.3	30.8
	Umuafor	5.9	26	4.1 + 0.7	42.1	24.0	42.7
Ihitte	Isinwaeke	5.8	26	5.1 + 0.1	38.6	24.8	80.3
	Amakohia	6.0	30	6.4 + 0.4	24.7	32.4	38.0
	Umuihi	5.5	28	5.1 + 0.3	27.4	27.9	26.7
	Aboeke	6.9	27	5.4+ 0.5	47.5	30.4	40.7
Okigwe	Ope	5.4	30	4.3 + 0.2	28.9	38.9	38.1
	Ubahaa	6.0	31	3.7 + 0.1	31.4	33.3	31.7
	Umuka	6.8	29	3.1 + 0.7	34.6	32.8	34.2
	Umuokpara	5.3	29	4.6 + 0.5	33.3	50.6	41.1
Ehime	Umuezeala	5.9	30	4.6 + 0.5	32.4	21.3	28.9
	Umueze II	5.5	26	5.1 + 0.1	46.3	29.8	36.5
	Agbja	5.7	26	4.7 + 0.2	40.3	42.3	29.1
	Umunakuru	6.7	27	Nil	24.3	40.8	32.4
Isiala	Anara	5.5	28	2.8 + 0.3	25.6	23.6	56.0
	Amaraku	6.0	29	3.3 + 0.1	19.9	45.4	35.4
	Ugiri	5.8	30	6.2 + 0.8	27.3	38.9	47.4
	Umunkwo	6.7	26	7.2 + 0.9	18.4	42.3	43.2

Table 8: Comparison of Results for the Three Treatment Methods

PH			
B4 TRT	CHL	8-stp	PRB
6.3	6.4	7	7.4
5.9	5.9	6.5	8
5.8	6	6	6.8
6.1	6.3	6.4	6.6
6.2	6.4	6.5	6.8
5.7	5.9	6.2	7.3
6.4	6.5	6.6	7.1
5.8	5.9	5.9	8.4
6.5	6.7	6.6	8.6

TURBIDITY			
B4 TRT	CHL	8-stp	PRB
5.2	4.1	5	3
6.4	4.8	4.3	4.2
7	3.7	3.7	2.1
8.2	5.2	3.1	2.3
6.7	4.7	4.6	1.8
5.6	5	5.1	2
6.5	4.5	4.7	1.3
8.1	5.1	4.5	1.5
4.4	4.4	2.8	2.3

5.4	5.5	5.9	6.4
5	5.3	5.2	7.5
6.2	6.4	6.1	8.9
6.4	6.5	6.5	6.7
6.8	6.8	6.9	6.3
7.3	7.5	7.5	7.6
6.6	6.7	6.7	7.9
5.3	5.4	5.4	8.2
6.1	6.4	6.4	8.7
6.9	6.9	6.8	6.4
5.8	5.7	5.9	6.9
6	6.2	6	7.1
5.8	5.9	5.6	7.8
7.2	7.2	7.5	8.3
7.1	7.4	7.4	6.9
6.8	6.7	6.9	7.9
6	6.2	6.2	8.2
6.4	6.4	6.6	7.4
5.4	5.5	5.7	6.8
5.8	5.7	6	6.7
5.2	5.6	5.6	6.4
6.6	6.4	6.7	8.5
5.7	5.5	5.9	8.1
5.5	5.8	5.6	7.8
5.2	5.5	5.4	6.5
6	6.4	6	6.3
6.7	6.5	6.5	8.4
6.4	6.3	6.5	7.3
6.2	6.4	6.4	7.7
5.9	6.2	6	8.8
6.8	6.9	6.7	7.6
5.9	6.1	5.8	6.9
6.3	6.4	6.4	6.6
5.3	5.5	5.5	6.2
6.2	6.3	6.3	7.9
5.2	5.5	5.6	6.8
5	5.4	5.2	6

3.8	3.8	3.3	1.1
8.9	4.9	4.5	2
4	4	6.2	1.3
6.6	3.6	7.2	2.5
7.2	5.2	6	3
8	5	3.8	3.2
5.8	4.8	4	2.5
4.7	4.7	6.7	2.1
5.1	5.1	5.5	1.8
6.2	4.2	4.6	1.9
7.2	5.2	5.4	2.4
3.2	3.2	6.7	1.3
0	0	5	0
4	4	4.8	21
3.8	3.8	6.3	1.2
5.7	5.7	6.5	2.5
4.9	4.9	4.3	2.1
3.7	3.7	6	2
3.9	3.9	3.5	1.7
8.5	4.5	0	2.1
7.4	4.4	4.4	3
3.5	3.5	3.9	1.2
0	0	4.1	0
4.7	4.7	8.3	2.4
8.3	5.3	7.2	1.9
6.1	5.1	6.2	2.2
6.6	4.6	4.5	3.1
4.6	4.6	5.2	1.7
4.9	4.9	6.4	1.1
4.5	4.5	5.4	2.3
8.7	6.7	3.7	1.8
5.2	5.2	6.9	2.3
6.2	4.2	5.1	3.4
4.8	4.8	6.4	4.1
7.2	6.2	5.1	5
4.8	4.8	5.4	2.6
5.9	5.9	4.3	2.1

TDS

B4 TRT	CHL	8-stp	PRB
87	27.4	45.6	10
65	28.5	51.7	12
76.2	24.5	26.9	16
71.3	30.7	24.8	14
80.3	44.3	18.3	18
64	50.7	24.8	11
58.6	52.4	40.6	13
81.9	30.7	41.6	10
90.7	51.7	37.8	11

HARDNESS

B4 TRT	CHL	8-stp	PRB
50.41	44.2	36.3	20.3
45.3	31.6	27.4	23.6
42.5	36.2	31	18.4
42.5	28.8	28.4	14
53.2	32.6	33.5	16.3
37.1	27.4	24.6	20
48.9	31.6	38.5	23.4
61.7	36.1	37.8	16.4
32.6	24.8	34.6	21.5

82	21.4	44.2	15
67.4	29.8	56.3	19.3
81.2	32.7	36.7	20
66.1	26.3	34.9	20
56.2	57	41	21
68.8	57.2	39.7	22
46.7	51.9	45.8	11
78.9	61.3	45.8	8
66.5	64.1	38.4	14
79.1	60.3	50.4	10
62.4	84.5	49.3	17
56	81.4	34.6	22
75.4	40.5	40.9	20
57.4	45	60.3	19
67	42.3	50.7	0
57.5	80.3	48.1	13
48	38	43.7	25
61.3	26.7	38.9	21
70.2	40.7	51.6	12
63.3	38.1	44.8	18.9
58.9	31.7	43	13.6
59.3	34.2	37.6	11.4
48.1	41.1	42.1	10.2
30.4	34.3	38.7	14.8
49.1	44.5	49.9	0
44.3	42.1	50.6	32.6
50.4	40	60.5	26.4
66.7	50.1	42.8	30.3
73.4	48.3	31.7	21.8
74.5	36.7	60.5	24.5
86.2	40.2	46.7	16.8
62.4	80.3	48.6	36.7
50.5	72.3	44.6	0
39.8	60.2	37.1	19.5
57.7	30.8	57.7	27.4
41.3	42.7	41.3	20.3
66.2	20.4	66.2	35.6

28.7	36.4	33.6	19.3
55.3	41.5	40	24.5
60.4	40.2	44.2	26.3
38.9	37.5	31.6	18.4
24.5	42.3	36.2	12.3
28.1	45.6	28.8	17.5
30.6	40.3	32.6	26.3
38.7	38.4	27.4	21.7
43.4	20.4	31.6	16.8
52.3	30.3	36.1	26.3
63.9	28.3	24.8	32.2
42.1	24	36.4	19.3
45.6	27.3	41.5	24.1
51.7	30.1	40.2	29.8
26.9	44.2	37.5	19.3
24.8	31.6	42.3	28.3
18.3	36.2	45.6	26.1
24.8	28.8	40.3	14.3
40.6	32.6	38.4	15.4
41.6	27.4	20.4	13.5
37.8	31.6	30.3	14.3
44.2	36.1	28.3	11.2
56.3	24.8	24	13.2
36.7	36.4	27.3	17.1
34.9	41.5	30.1	20.2
41	40.2	24.3	18.5
39.7	37.5	32	18.5
45.8	42.3	22.3	16.4
45.8	45.6	25.6	14.6
38.4	40.3	26.3	20.3
50.4	38.4	35.3	25.4
49.3	20.4	36.8	19.3
34.6	30.3	28.9	14.7
40.9	28.3	25.9	10.3
60.3	24	30.8	11.4
50.7	27.3	20.9	13.7
48.1	30.1	60.5	17.3

Na

B4 TRT	CHL	8-stp	PRB
2.68	3.61	5.1	3.74
3.44	2.84	3.01	4.23
2.96	3.02	2	3.61
2.54	3.32	4.09	2.84
3.69	4.12	3.21	3.02
2.99	5.2	3.41	3.32
3.93	6.31	5	4.12
4.01	5.46	6.45	5.2
4.56	4.09	4.21	6.31
3.3	5.24	6.89	5.46
3.2	4.27	3.68	4.09
3.56	2.28	2.45	5.24
3.11	4.13	6.34	4.27
2.23	3.21	4.21	2.28
3.97	6.12	7.12	3.46
3.09	5.34	6.1	4.56
2.1	4.23	3.16	3.27
0	3.49	4.12	0
2.03	3.24	3.89	3.24
2.45	4.06	4.06	4.06
0	0	0	0
2.67	3.06	4.12	3.06
2.05	3.34	4.56	3.34
3.98	0	0	0
3	5.01	6.21	5.01
2.28	4.32	5.4	4.32
3.5	3.46	5.23	3.46
3.4	3.62	3.83	3.62
0	0	0	0
2.4	2.64	3.57	2.64
1.36	2.4	2.48	2.4
2.16	3.61	4.71	3.61
2.94	3.84	4.65	3.84
0	0	0	0

SO4

B4 TRT	CHL	8-stp	PRB
20	5.2	5.2	4.8
10.4	5.9	5.9	4.5
8.3	3.5	3.5	6.3
6.7	4.5	4.5	4.2
4.8	3.5	3.5	3.9
0	0	0	0
8.6	4.8	4.8	5.1
5.3	4.5	4.5	4.1
19.7	6.3	6.3	7.1
18.5	4.2	4.2	9.9
0	0	0	0
13.7	6.4	4.6	6.8
14.9	2.8	4.8	5.9
13.2	4.8	4.7	8.1
3.9	2.1	3.2	2.1
0	3.9	4.8	0
11.8	0	0	5.4
2.7	5.9	5.9	2
6.4	8.1	8.1	4.8
3.6	2.1	2.1	3.1
0	0	0	0
4.5	3.4	3.4	3.8
3.8	4.9	4.9	2.4
7.2	5.8	5.8	5.7
6.1	6.1	6.1	7.4
5.3	4.9	4.9	4.6
0	0	0	0
5.6	4.7	4.7	3.7
3.4	5.9	5.9	2.9
6.7	7.6	7.6	4.6
0	0	0	0
5.8	6.6	6.6	4.6
4.6	8.3	8.3	3.1
3.9	4	4	3

3.75	4.12	5.05	4.12
2.86	4.16	5.34	4.16
0	0	0	0
2.93	2.14	2.14	2.14
2.33	3.47	3.47	3.47
3.12	3.56	3.56	3.56
2.98	4.12	4.12	4.12
1.86	3.64	3.64	3.64
2.49	3.16	3.16	3.16
3.01	4.14	4.14	4.14
0	0	0	0
2.79	3.74	5.1	3.42

4.2	3.5	3.5	3.4
4.2	0	0	0
10.7	6.4	6.4	4.6
5.1	4.5	4.5	3.9
13.6	5.3	5.3	5.9
0	0	0	0
7.7	3.9	3.9	2.9
18.2	4.7	4.7	9.9
0	0	0	0
4.3	3.2	3.2	2.8
12.8	4.3	4.3	8.1
14.7	4.1	4.1	3.9

EC

B4 TRT	CHL	8-stp	PRB
98	80.3	57	50.4
118.5	72.3	57.2	45.3
93.7	60.2	51.9	42.5
91.6	60.8	60.3	42.5
112.8	42.7	60.3	53.2
96.7	80.4	60.3	37.1
115.5	36.8	84.5	48.9
102.6	86.9	81.4	61.7
89.9	28.4	40.5	32.6
98.4	49.2	45	28.7
100.1	53.7	42.3	55.3
122.7	50.4	80.3	60.4
88.9	72.8	38	38.9
74.6	60.5	26.7	24.5
83.6	42.6	40.7	28.1
101.2	74.8	38.1	30.6
120.3	80.1	31.7	38.7
100.7	60.5	34.2	43.4
90.6	41.4	41.1	52.3
98.7	58.8	34.3	63.9
111.7	44.6	44.5	42.1

CA

B4 TRT	CHL	8-stp	PRB
30	33.2	38.4	56.2
33.6	34.4	39.3	47.3
44.2	21.3	44.5	49.3
61.6	37.2	36.3	36.5
62.4	28.6	45.2	52.2
52.4	34.5	44.7	34.7
45.2	36.3	37.3	27.3
62.6	35.2	48.9	48.1
38.8	43.7	49.4	29.7
32.6	40.2	56.2	60.2
41	41.2	47.3	51.6
35.6	35.7	49.3	38.3
49.8	26.1	36.5	46.1
60.4	29.2	52.2	39.2
43.2	28.1	34.7	38.4
41.4	34.1	27.3	44.6
21.6	33.2	48.1	43.9
30.6	34.4	29.7	34.4
28.6	21.3	30.2	36.8
25.2	37.2	51.6	47.2
23.6	28.6	35.7	48.6

122.1	56.1	42.1	45.6
104.6	62.6	40	51.7
99.9	49.7	50.1	26.9
103.8	61.2	48.3	24.8
98.4	53.4	36.7	18.3
117.6	67.6	40.2	24.8
94.6	44.6	80.3	40.6
97.6	77.6	72.3	41.6
95.8	55.8	60.2	37.8
89.7	69.7	30.8	44.2
78.4	48.4	42.7	56.3
102.6	39.6	20.4	36.7
113.4	73.4	36.8	34.9
140.6	55.6	16.9	41
120.7	50.7	28.4	39.7
99.1	69.1	49.2	45.8
98.4	58.4	53.7	45.8
104.6	49.6	50.4	38.4
130.1	60.1	18.9	50.4
120	62	27.7	49.3
94.6	54.6	29	34.6
97.5	47.5	30.4	40.9
96.5	66.5	31.2	60.3
89	69	30	50.7
78.6	58.6	26.2	48.1

25.8	34.5	26.1	44.5
31.8	36.3	29.2	46.3
36.6	35.2	28.1	55.2
29.2	56.2	34.1	55.8
27.4	47.3	33.2	58.7
39.4	49.3	34.4	43.5
37.8	36.5	21.3	38.7
40	52.2	37.2	47.9
38.8	34.7	28.6	46.5
30.8	27.3	34.5	54.3
32	48.1	36.3	56
24.6	29.7	35.2	44.7
29	60.2	57.4	46.8
35.4	51.6	56.2	49.4
35.4	35.7	47.3	40.5
44.8	26.1	49.3	38.1
27.6	29.2	36.5	35.6
51.8	28.1	52.2	44.3
33.4	34.1	34.7	34.9
23.6	33.2	56.2	48.5
26.8	34.4	47.3	46.4
27.2	21.3	49.3	44.7
37.6	37.2	36.5	55.4
25	28.6	52.2	57.4
77.8	34.5	34.7	48.6

ZN

B4 TRT	CHL	8-stp	PRB
1.2	0.4	1	1.3
0.8	0.6	0.8	1.2
1.1	0.7	1	1.1
0.6	0.3	0.7	1
0.7	0.3	0.5	0.8
1.2	0.5	1	0.7
1.1	0.8	1.1	0.5
0.9	0.4	0.8	0.6

Pb

B4 TRT	CHL	8-stp	PRB
0.03	0.02	0.02	0.011
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0.02	0.15	0.12	0.1
0	0	0	0
0	0	0	0

0.7	0.5	0.5	1.6	0	0	0	0
0.6	0.6	0.4	1.2	0	0	0	0
0.8	0.5	0.7	0.9	0.02	0.011	0.01	0.01
1.1	0.1	1	1.2	0	0	0	0
1.4	0.7	1.1	0.8	0	0	0	0
1.2	0.3	1	0.7	0	0	0	0
0.8	9	0.3	1.2	0	0	0	0
0.7	0.4	0.5	1	0	0	0	0
0.6	0.3	0.3	1.3	0	0	0	0
1.3	0.8	1	1.2	0	0	0	0
1.3	0.9	1.1	1.1	0	0	0	0
1.8	0.7	0.9	1	0	0	0	0
2	0.3	1.2	0.8	0.02	0.01	0.011	0.01
1.7	0.5	1.1	1.7	0	0	0	0
1.5	0.1	1.2	1.5	0	0	0	0
0.8	0.2	0.5	0.6	0	0	0	0
0.7	0.3	0.6	1.6	0	0	0	0
1.1	0.1	1.2	1.2	0	0	0	0
1.2	0.1	1.2	0.9	0	0	0	0
0.8	0.1	0.5	1.2	0.03	0.02	0.02	0.02
1.4	0.7	1.1	0.8	0.03	0.01	0.01	0.01
1	0.1	1.1	0.7	0	0	0	0
0.8	0.2	0.6	1.2	0	0	0	0
0.7	0.1	0.4	1	0	0	0	0
1.4	0.2	1	0.7	0.02	0.07	0.07	0.07
1.1	0.1	1.2	0.8	0	0	0	0
0.6	0.1	0.3	1.3	0.03	0.02	0.02	0.02
0.6	0.2	0.2	0.8	0.03	0.01	0.01	0.01
0.8	0.3	0.5	1.1	0.02	0.01	0.01	0.01
1.1	0.2	0.4	0.8	0	0	0	0
1.2	0.4	0.4	1.3	0.02	0.02	0.02	0.02
1.6	0.3	1.3	1.1	0.02	0.02	0.02	0.02
0.8	0.2	0.4	1	0.03	0.02	0.02	0.02
0.6	0.1	0.5	0.8	0.02	0.01	0.01	0.01
0.7	0.3	0.6	1.6	0.02	0.01	0.01	0.01
0.9	0.7	0.6	1.2	0	0	0	0
0.8	0.8	0.4	0.9	0	0	0	0

0.8	0.9	0.6	1.2

0	0	0	0

Fe

B4 TRT	CHL	8-stp	PRB
0.1	0.2	0.26	0.28
0.2	0.21	0.21	0.3
0.28	0.23	0.29	0.41
0.11	0.2	0.32	0.33
0.14	0.32	0.43	0.2
0.44	0.43	0.1	0.6
0.51	0.1	0.12	0.8
0.15	0.12	0.19	0.25
0.81	0.19	0.2	0.8
0.29	0.2	0.18	0.31
0.3	0.18	0.23	0.4
0.28	0.23	0.26	0.32
0.2	0.26	0.16	0.3
0.31	0.16	0.32	0.4
0.39	0.32	0.21	0.42
0.15	0.21	0.33	0.2
0	0	0	0
0.3	0.26	0.26	0.33
0.2	0.21	0.21	0.28
0.3	0.29	0.29	0.31
0.21	0.24	0.24	0.2
0.24	0.22	0.22	0.26
0.3	0.24	0.24	0.35
0.32	0.25	0.25	0.3
0.16	0.21	0.21	0.21
0.36	0.16	0.16	0.41
0.22	0.23	0.23	0.2
0.32	0.21	0.21	0.28
0.4	0.32	0.32	0.42
0.36	0.26	0.26	0.3
0.24	0.24	0.24	0.28
0.3	0.21	0.21	0.35

Mg

B4 TRT	CHL	8-stp	PRB
2.01	4.62	5.02	2.3
1.8	2.43	3.23	2.04
0.95	1.08	1.03	1.56
0.97	1.82	2.81	1.5
2.4	2	4.62	2.54
2.61	1.46	2.43	3.02
1.7	1.32	1.08	1.89
1.22	1.08	1.82	1.46
4.62	2.99	2	4.83
2.43	2.36	1.46	2.72
1.08	2.1	1.32	1.26
1.82	4.22	1.08	2
2	3.02	2.99	2.32
1.46	2.05	2.36	1.63
1.32	1.81	2.1	1.28
1.08	4.24	4.22	1.64
2.99	3.02	3.02	1.89
2.36	2.05	2.05	2.57
2.1	1.81	1.81	2.45
4.2	2.26	4.24	4.66
3.02	2.58	3.02	4.21
2.05	1.92	2.05	3.01
1.81	2.83	1.81	2.04
2.2	1.06	2.26	2.32
2.5	1.88	2.58	3.62
1.92	2.09	1.92	2.77
2.83	3.02	2.83	3.04
1.06	1.86	1.06	1.43
1.88	2.11	1.88	2.44
2.09	2.04	2.09	2.48
3.02	3.03	3.02	3.36
1.86	1.84	1.86	2.8

0.28	0.16	0.33	0.16
0.12	0.21	0.25	0.2
0.26	0.3	0.16	0.3
0.26	0.2	0.05	0.2
0.4	0.2	0.27	0.43
0.3	0.31	0.31	0.25
0.2	0.23	0.38	0.08
0.3	0.2	0.41	0.36
0.36	0.32	0.32	0.38
0.23	0.43	0.43	0.08
0.36	0.1	0.1	0.38
0.32	0.12	0.12	0.36
0.38	0.19	0.19	0.43
0.24	0.2	0.2	0.31

2.11	2.08	1.02	2.32
2.04	2.22	3.15	3.56
3.03	1.84	1.21	4.24
1.84	2.48	3.21	3.21
2.08	3.01	3.02	3.67
2.22	2.21	2.05	2.82
1.84	2.56	1.81	2.73
2.48	1.92	1.92	3.21
3.01	2.83	4.62	3.63
1.24	1.06	2.43	2.06
1.76	1.88	1.08	1.34
1.78	2.09	1.82	2.34
1.82	3.02	2	2.96
2.11	1.86	1.46	2.7

Na

B4 TRT	CHL	8-stp	PRB
2.68	3.61	5.1	3.74
3.44	2.84	3.01	4.23
2.96	3.02	2	3.61
2.54	3.32	4.09	2.84
3.69	4.12	3.21	3.02
2.99	5.2	3.41	3.32
3.93	6.31	5	4.12
4.01	5.46	6.45	5.2
4.56	4.09	4.21	6.31
3.3	5.24	6.89	5.46
3.2	4.27	3.68	4.09
3.56	2.28	2.45	5.24
3.11	4.13	6.34	4.27
2.23	3.21	4.21	2.28
3.97	6.12	7.12	3.46
3.09	5.34	6.1	4.56
2.1	4.23	3.16	3.27
0	3.49	4.12	0
2.03	3.24	3.89	3.24

SO4

B4 TRT	CHL	8-stp	PRB
20	5.2	5.2	4.8
10.4	5.9	5.9	4.5
8.3	3.5	3.5	6.3
6.7	4.5	4.5	4.2
4.8	3.5	3.5	3.9
0	0	0	0
8.6	4.8	4.8	5.1
5.3	4.5	4.5	4.1
19.7	6.3	6.3	7.1
18.5	4.2	4.2	9.9
0	0	0	0
13.7	6.4	4.6	6.8
14.9	2.8	4.8	5.9
13.2	4.8	4.7	8.1
3.9	2.1	3.2	2.1
0	3.9	4.8	0
11.8	0	0	5.4
2.7	5.9	5.9	2
6.4	8.1	8.1	4.8

2.45	4.06	4.06	4.06
0	0	0	0
2.67	3.06	4.12	3.06
2.05	3.34	4.56	3.34
3.98	0	0	0
3	5.01	6.21	5.01
2.28	4.32	5.4	4.32
3.5	3.46	5.23	3.46
3.4	3.62	3.83	3.62
0	0	0	0
2.4	2.64	3.57	2.64
1.36	2.4	2.48	2.4
2.16	3.61	4.71	3.61
2.94	3.84	4.65	3.84
0	0	0	0
3.75	4.12	5.05	4.12
2.86	4.16	5.34	4.16
0	0	0	0
2.93	2.14	2.14	2.14
2.33	3.47	3.47	3.47
3.12	3.56	3.56	3.56
2.98	4.12	4.12	4.12
1.86	3.64	3.64	3.64
2.49	3.16	3.16	3.16
3.01	4.14	4.14	4.14
0	0	0	0
2.79	3.74	5.1	3.42
	PO4		
B4 TRT	CHL	8-stp	PRB
4.5	5.9	4.6	5.2
3.9	3.5	4.8	6.1
4.8	4.5	4.7	4.9
2.9	3.9	3.2	5
8.4	2.2	4.8	8.6
7.6	4.6	2.6	9.2
5	2.2	2.7	5.2
4.4	4.7	5	5.9

3.6	2.1	2.1	3.1
0	0	0	0
4.5	3.4	3.4	3.8
3.8	4.9	4.9	2.4
7.2	5.8	5.8	5.7
6.1	6.1	6.1	7.4
5.3	4.9	4.9	4.6
0	0	0	0
5.6	4.7	4.7	3.7
3.4	5.9	5.9	2.9
6.7	7.6	7.6	4.6
0	0	0	0
5.8	6.6	6.6	4.6
4.6	8.3	8.3	3.1
3.9	4	4	3
4.2	3.5	3.5	3.4
4.2	0	0	0
10.7	6.4	6.4	4.6
5.1	4.5	4.5	3.9
13.6	5.3	5.3	5.9
0	0	0	0
7.7	3.9	3.9	2.9
18.2	4.7	4.7	9.9
0	0	0	0
4.3	3.2	3.2	2.8
12.8	4.3	4.3	8.1
14.7	4.1	4.1	3.9
	Cl		
B4 TRT	CHL	8-stp	PRB
5.1	6.2	10.3	5.4
3.2	5	6.7	3.5
2.42	6.7	8.4	3
3.6	7.2	7.4	4.18
0	0	0	0
2.81	8.4	7.4	2.6
3.6	3.1	8.9	4.34
3.44	10.8	6.1	4

3.2	5.3	4.9	3.5
3	2.6	4.2	4.5
2.8	2.7	4.3	3.9
2.7	5	3.4	2.2
1.8	4.9	2.7	2.1
4.9	4	4.6	4.4
3.6	4.3	4.6	4.3
2.6	3.4	4.8	3.4
2.3	2.7	4.7	2.7
3.2	4.6	3.2	4.6
1.6	2.2	4.8	2.2
4.5	4.7	4.7	4.7
3.8	5.3	5.3	5.3
2.7	2.6	2.6	2.6
2.4	2.7	2.7	2.7
3.3	5	5.4	5
4.1	4.9	4.9	4.9
3.5	4	4.6	4
4.2	5.4	5.4	5.4
0	0	0	0
0	0	0	0
4.3	5.3	5.3	5.3
3.6	4.8	4.8	4.8
4.8	5.9	5.9	5.9
0	0	0	0
5	6	4.6	6
2.3	3	4.8	3
2.3	2.9	4.7	2.9
3.3	4.9	3.2	4.9
0	0	4.8	0
2.8	4	4	4
1.7	2.1	2.1	2.1
5.2	4.7	4.7	4.7
0	0	0	0
3.7	4.6	4.6	4.6
2.9	4.8	4.8	4
3	4.7	4.7	4.7

2.5	7.6	7.2	3.2
4.05	6.2	9.4	4.6
0	5	7.7	0
5.54	6.7	8.6	6
8.58	7.2	9.8	9.1
5.24	8.7	9.4	5.8
6.51	8.2	4.9	7
13.7	8.1	6.7	14.1
11.2	10.8	9.5	11.6
8.71	14.6	9.7	9.1
8.06	6.2	8.8	8.8
0	6.4	6.4	0
6.15	4.1	10.3	6.6
7.34	7.6	6.7	8.1
8.24	5.6	8.4	8.87
6.13	3.4	7.4	6.9
5.12	2.6	8.3	5.4
0	6.1	7.4	0
4.64	5.5	8.9	5
5.26	10.9	6.1	8.62
4	7.8	7.2	4.7
6.7	6.4	9.4	6.84
8.3	8.4	7.7	8.4
9.4	9.7	8.6	10
10	9	9.8	9.8
11	5.4	9.4	9
8.4	4.9	4.9	8.99
8.4	4.2	6.7	9
4.9	3.4	9.5	5.4
8.9	6.6	9.7	8.56
7.2	7.4	8.8	7.84
6.1	3.2	5.2	6.2
7.3	4.2	6.2	7.52
8.5	6.1	6.1	9
4.7	3.4	7.4	5
3.4	4.8	9.8	4
2.8	2.6	8.6	3

2.1	3.2	3.2	3

0	0	0	0

NO3

B4 TRT	CHL	8-stp	PRB
4.8	8.6	4.6	2.1
5.4	9.2	4.8	3.5
6.5	5.2	4.7	4.6
4.2	3.9	3.2	2.1
3.8	4.5	4.8	2.3
2.7	6.5	4.6	1.7
1.8	6.9	2.2	1.6
4.8	7.2	4.7	2.1
3.2	8.1	5.3	2
7.5	4.4	2.6	5.8
8.2	3.6	4.6	2.6
3.4	4.2	4.8	3.2
7.2	4.5	4.7	4.2
4.1	5.6	3.2	3.2
3.8	2.4	4.8	2
2.9	4.8	3.4	1.8
3.5	5.6	2.7	3
4.6	5.3	4.6	3.5
7	2.6	5.9	4.2
5.4	2.7	3.5	3.1
6.6	5.3	4.5	3.9
5.4	4.9	3.9	4.1
8.3	4.1	2.2	3
2.7	2.6	5.9	2.4
4.6	3.2	3.5	2
3.5	3.4	4.5	2.2
6.4	3.1	3.9	3.1
6.5	2.3	2.2	4.9
10.2	2.9	4.6	7.4
8.4	2.1	2.2	4.9
4.1	3.8	4.7	3.1
3.6	2.3	4.6	2.3

5.2	3.4	4.8	3.5
3.7	5.3	4.7	2.2
63	4.3	3.2	3.6
63	4.1	4.8	4.1
8.6	5.3	5.3	5
6.8	4.9	4.9	4.2
14.8	2.6	2.6	7.8
13.3	4.8	4.8	6.9
4.2	5.2	4.6	2.3
7.6	2.7	4.8	3
5.8	2.4	4.7	2.8
8.3	5.8	3.2	4.4
4.9	4.4	4.8	3.5
5.3	4.7	4.6	1.9