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Inaugural Lectures Series 9

DRINKING WATER OR SEWAGE

Is there a Difference?

by Kenneth E. Damann

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Kenneth E. Damann

Professor of Microbiology

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Introduction

Thirty years ago, armed with a bright new shiny Ph.D. degree from Northwestern University at Evanston, Illinois, I accepted my first professional position as a Sanitary Engineer in the Water Purification Division of the City of Chicago. My major responsibility was to organize and maintain a Water Control Laboratory that would evaluate the quality of water supplied to over four million residents of Chicago and its suburbs.

As a follow up on Professor S. A. Aluko's previous inaugural lecture, *Money in Economy Theory*, I might add that at that time I had a choice of working as an instructor at Northwestern University with an annual salary of $1,800 or approximately 600 Nigerian pounds. The janitors or cleaning people at Northwestern were receiving salaries higher than instructors so I chose to become a Sanitary Engineer for the City of Chicago. You can imagine my surprise when I distributed the first pay checks to my staff and discovered that the dishwasher in the bacteriology laboratory received a larger amount than I did for the first month in spite of my Ph.D. degree. However, I liked the work so continued on for four years before returning to academic life of the university at a somewhat reduced salary from that of a Sanitary Engineer. It is encouraging to report that in recent years the trend has changed and parity in remuneration in various professions is becoming more and more evident.

I would like to pause here and have a few words directly with the students because I think there is a moral involved with my experiences that might well effect the future of many of them. It is simply this .... don't expect your Bachelors, Masters or even your Ph.D. Degrees to be passports to wealth and a good job. They are only the beginning. It is actually what you do after the degrees that really counts and it is probably more important that you like what you are doing for then your job becomes fun and is not work. Saying it a bit differently .... on the desk of one of the Mayo Brothers of the internationally famous Mayo Clinic at Rochester, Minnesota was this motto .... "There is no fun like work". With such an attitude you can see how he reached the top where there is always room. It is at the bottom, where everybody wants something for nothing, that you will find the real competition in life.

When my work as a Sanitary Engineer ceased to be fun, I returned to the classroom at a University where my work was fun; but, I have maintained more than just an academic interest in water and sewage for these many years. During the long summer vacation of 1950, I was sent on a sanitary survey of the mighty Missouri River Basin by the United States Public Health Service. It was on this assignment that I witnessed a wide variety of practices of handling water and sewage from the most primitive methods practised by the American Indians to the most modern employed by the large urban areas of Kansas City and St. Louis, Missouri. However, I must confess that the sanitary conditions observed on my first trip through the streets of Lagos have had no equal. The presence of filth in the open drainage ditches and the manner in which "night soil" is disposed of in Lagos has been cause for some serious reservations in thought as to the importance that has been placed upon pollution, and its apparent delitescent effect upon the well being of mankind. I have asked myself several times since coming to Nigeria, is it possible that we in the United States have been over emphasizing the need for some of our modern sanitation practices? I think not and, in spite of the survival of the inhabitants of Lagos, I shall try to make a case for the application of more improved methods of handling both water and sewage here in Nigeria and specifically on the University of Ife Campus.

With so much concern being expressed all over the world about the spoiling of our environment, the critical problem in most societies today is the providing of an adequate and safe water supply for human consumption. Since 1500 B.C., when Moses smote the rock and water gushed forth, many fanciful ideas or beliefs have been associated with water. In the old arid countries water played an important role in the religious and social life of the people. Temples and shrines were built at wells and springs. When a good well was completed, the event was usually celebrated with great rejoicing. Refusing a drink to a thirsty person, whether friend or foe, was a grave offence. It was suggested by some that spirits, both good and evil, inhabited certain waters. Thus, well worship, body healing and witchcraft practices were common.

Many of the ancient notions about water had a bit of truth associated with them; but, probably more often, they were conjured up without any supporting facts. It was believed that water was drawn from a well with a bucket and rope because the splashing by the bucket kept the water from becoming stagnant. Early sailors believed that salt water would not extinguish a fire and drinking it would cause insanity. In some regions persons believed goiters were caused by drinking melted ice or snow water while still others thought malaria was caused by drinking stagnant water.

At one time in England, it was believed that the dangerous qualities of polluted water could be obviated by adding or drinking wine or similar spirits. This practice became so widespread that the government had to issue a memorandum correcting this misbelief.

Some people thought that drinking water after eating fruit was poisonous. While we now may smile at some of these old beliefs, yet today similar fanciful ideas about water and health still persist. The waterwitch still plies his trade and has many believers. Some people think that because a water issues forth from the ground as a spring that it is safe to drink. Others drink only bottled mineral water for their good health, while in Ife many drink palm wine diluted with water, and I hope for the same good reason.

In the book of Samuel (23: 15-17) you can read that David's desire for a drink of water from a certain Bethlehem well resulted in bloodshed when three of his followers broke through the Philistine lines to obtain it. While this happened some three thousand years ago, water was still making history in 1941 when the British shelled the wells of the Italian held town of Tobruk in order to hasten their surrender.

Starved Rock State Park, a well known recreational area in central United States, was so named because one rival band of Indians held another tribe on a rock cliff above a river until they perished. Each time they would lower their buckets to the river for water the attackers would cut the ropes and in due time they all died from lack of water according to legend. An occasional water shortage on the University of lfe campus serves to remind us all of the importance of water as we are forced to go without or live on a very limited stored supply.

Water Versus Sewage

Since a water supply is the foundation upon which rests your health then knowing that your drinking water is pure and safe to drink is a primary duty of every person. The first questions that need answering are *What is Water* and *What is Sewage?* Is there a difference?

Mathematically, the difference between water and sewage is often only six inches or less depending upon the distance from the water tap to the drain or basin of a sink. For example, you may draw a glass of water from the tap and that portion you consume is drinking water. Should you choose not to drink it all and empty a portion in the sink then suddenly drinking water has become sewage or part of the product we will refer to as sewage.

In reality sewage is not necessarily an offensive product. It consists of approximately 99.9 per cent water and the remaining 0.1 per cent is composed of mostly organic and some inorganic matter. The one tenth percent includes human wastes, garbage, cleaning solvents, greases, etc. as organic constituents; while sand, silt, mud and cinders contribute to the inorganic material. Therefore, it should seem reasonable to assume that if sewage is made up of 99.9 percent water, then sewage is a condition in which water finds itself, rather than a new and different product. Stated more simply, water is the vehicle for carrying waste materials. To further illustrate the point, sewage has been very simply described as a stream of water flowing through homes, factories and businesses of a community into which waste materials are discharged. Then downstream there is a treatment plant which removes the wastes so the next town can process the stream water for drinking and the many other uses of every day living.

It seems obvious, therefore, that we must be realistic and accept the fact that water is not really consumed by man but actually used over and over again. At the present time, the water of the Mahoning River passing through Ohio and Pennsylvania is reused eight times in less than 100 miles before reaching the Ohio River and then at least twice again before the Ohio joins the Mississippi River. I am sure that similar figures can be quoted for the water of River Niger as well as the small rivers and their tributaries as they pass by native villages enroute to the ocean.

If you are unable to accept such conditions as a way of life, then you will not be eligible for a passage on any of the moon flight excursions in the near future. Lunar passengers will have to agree to recycling of all waste materials as a matter of routine before being welcomed aboard a space ship.

Water Quality Testing

Now that we have established that sewage is a condition that water finds itself, how are we going to evaluate its condition; namely, drinking water or sewage? And are there any categories in between? Unfortunately, it is impossible to look at a sample of water, even with our most modern microscopes, and decide on its quality. There are no chemical tests or electronic devices that can give us instantaneous results. Therefore, for want of a better yardstick, we have to seek out the bacteria present and determine their kind and number before passing any judgment. This is a very time consuming procedure. Prior to 1945, as much as seven days were required to complete the analysis according to methods approved by the United States Public Health Service. One should immediately ask, what good is a water quality test that takes seven days to complete when you do not retain the water for the same length of time but drink it daily. The only answer is that no better or more reliable test was available to the water bacteriologist at that time. This actually made the water bacteriologist a historian because he was collecting records and reporting on water already consumed as much as one week prior to reporting the results.

If all tests showed water of good quality with such a delayed testing procedure, then there were no problems and things went well. However, the report of a water sample that did not meet drinking water standards seven days previous was due cause for alarm. Immediately, the sanitary engineer, in charge of water treatment, checked his procedures and noted especially the amount of residual chlorine reported in the drinking water. Whatever it was the evidence points to it as being too low and this was a warning as to what the lowest limit of chlorine should not be. Our best safe guard to a pure drinking water is chlorine which should be added to the finished water as it leaves the water treatment plant in sufficient quantity, so that residual amounts of it are still present when the water reaches your domicile, place of work or public tap on the street. Only rarely have we been able to find even a trace of residual chlorine in the drinking water at the University of Ife. This is a very serious condition that needs attention and we will return to discuss its significance in more detail later.

The most recent procedures approved by Standard Methods for the analysis of water quality reduces the time from seven days to 18 hours, but we are still not able to look at the bacteria—even under the electron microscope—and make positive identification of bacteria causing typhoid fever, dysentery or cholera. Rather we look for a very common group of bacteria that inhabit the intestinal tract of man and other warm blooded animals naturally. These are referred to as enteric or coliform bacteria. There are many species included but the two most common are *Escherichia coli* and *Aerobacter aerogenes* and they are considered as fecal and non-fecal indicators of pollution, respectively.

The coliform group of bacteria are non-spore forming, short rods that are unable to retain a crystal violet stain when treated with alcohol; a condition referred to as Gram Negative. The fact that they ferment lactose sugar to produce a gas is almost unique for the group so this single medium constitutes the Presumptive Test. However, because there are one or two other species of bacteria that can ferment lactose, which do not have any sanitary significance, we have to do a Confirmed Test the results of which are expressed as Most Probable Number of Coliforms per 100 ml. (M.P.N.) and it is these values that are used to determine water quality by the old traditional method.

TABLE I

Significance of the Coliform Bacteria as a Measure of Pollution in Rivers and Lakes in United States *

Coliform Organisms per 100 ml.:	*Sanitary significance:*
0	Water free of pollution.
Not more than 1	U. S. Public Health Department limit for drinking water.
10 to 100	Indicative of good water, normal for inland and Great Lakes, free of sewage pollution.
100 to 500	Normal for inland streams, free of detrimental sewage pollution, might be attributed to land wash.
1,000	Suspicious — generally indicates mild pollution in natural waters but dangerous in proximity to fresh sewage pollution.
10,000	Definite evidence of fresh sewage pollution, a *Menace to Health*
100,000	Heavy sewage pollution — definitely dangerous.
1,000,000	Normal for sewage.

* The above limits were established by the Great Lakes Board of Engineers in the United States.

The new Millipore Filter Technique with specialized enrichment media for various groups of bacteria allows for making direct counts in 18 hours of specific bacteria rather than relying on the mathematical Most Probable Number expressions. However, regardless of the method used in the determination of coliforms, bacteriologically speaking, the difference between Drinking Water and Sewage depends upon the number of coliform bacteria present. Water with one or less than one coliform per 100 ml. (small tea cup) is considered safe to drink while the same amount of water with a 1,000,000 coliforms is considered normal for raw sewage. Populations of a 1,000 coliforms suggest suspicious water quality while 10,000 is definite evidence of fresh sewage pollution and should be considered as a menace to health (Table I).

Significance of Coliform Bacteria

The rationale for allowing the presence of one or less than one coliform bacterium per 100 ml in safe drinking water needs some explanation. First, how can you have less than one bacterium per 100 ml? The answer is simply that you must increase the quantity of water examined and then find only one such bacterium in some amount greater than 100 ml. A more important question is why allow any of the coliform bacteria in our drinking water when it has already been established that they indicate the presence of fecal wastes?

Much research has been directed to this point and always with the pathogenic or disease bacteria in mind. It was found necessary to explore, first, the ratio of pathogenic bacteria to coliform bacteria occurring in raw sewage. Surprisingly, they found that approximately only one out of every million bacteria isolated from sewage proved to be a disease producer. This low frequency of occurrence gave the sanitary engineer a very large margin of safety. Thus, they assumed that in any water treatment process that eliminated 999,999 coliform bacteria per 100 ml out of a possible 1,000,000 that it would be unlikely that this particular one remaining bacterium would be a disease producing species. I find very little security with this kind of reasoning when the law of chance is applied in the final determination of whether or not our drinking water is safe for human consumption.

By comparison, it should be interesting to note at this time that the quality of milk we drink is also determined by the number of coliform bacteria present. However, the limits are quite different and we must recognize that dual standards are being used. Grade A milk can have over 900 times as many coliform bacteria present as found in safe drinking water and still be classified as the best quality of milk generally available in a community. To appreciate this great difference in standards you need to have had the experience of milking cows as I did as a boy growing up on a farm in Minnesota. You find that it is not at all difficult for bits of straw, dirt, flies and even manure from the cow to find their way into the open milk pail. Thus, the presence of a coliform bacterium in milk is far less significant than a coliform bacterium in your glass of drinking water; especially, if your water supply comes from a deep well. Here the route of the coliform bacterium would have to be from the intestine of some warm blooded animal, into and through the soil to the great depths necessary to reach the well and this would be a major accomplishment. Once more this is evidence that coliform bacteria do not hurt you or cause disease but are used merely as indicators of pollution wherever they are found.

Another major difference in judging milk quality relates to the fact that total number of bacteria occurring in the milk is also used to determine final grade or quality of the product. Grade A pasteurized milk must have less than 30,000 bacteria per ml at the time of delivery to the consumer in order to qualify as Grade A. On the other hand there is no limit as to the total number of bacteria occurring in safe drinking water. It should be remembered that only the coliform bacteria are used to judge water quality and decide whether it is safe or unsafe to drink.

What is meant by Water Quality and Pollution?

At this point you should be quite thoroughly confused as to the importance or significance of coliform bacteria. We have mentioned cholera, dysentery and typhoid as diseases associated with water but at no time have we tried to identify the bacteria causing these diseases. Rather we have looked for the easy to identify intestinal bacteria referred to as the Coliform Group. It is assumed that if coliform bacteria are present in a water supply then it is possible that the pathogenic species could also be present as they are natural inhabitants of the intestinal tract of those individuals known as carriers for a specific disease. Furthermore, the fecal coliform bacteria do not live long outside of the intestine, therefore, if you find *Escherichia coli* in your drinking water there is good evidence that the contamination is of recent origin. The source could be from a chicken, cow, horse, pig, dog, cat, goat or any other warm blooded animal and not necessarily man. All you know is that there is an avenue of contamination from an intestine leading into your water supply.

It is entirely possible that you could drink water harboring coliform bacteria the rest of your life and never suffer any ill effects. However, if some person carrying the typhoid or cholera bacteria should visit your village or premises and chance to use your sanitary facilities, it is possible that bacteria causing diseases could find their way into the water supply along with the coliforms and the entire village could be stricken with an epidemic. A rather crude analogy might be explored here; namely, drinking water with coliforms present is like wiring your house for electricity with bare or uninsulated wires. You might live very happily for the rest of your life, but chances are rather good that sooner or later something could fall across those bare wires causing a short circuit and possibly burn your house to the ground. You are likewise living just as dangerously when you continue to drink water containing coliform bacteria which are indicators of pollution only. One never knows when the real deadly pathogens might find their way into the water supply along the same route followed by the coliforms.

Problems related to the recycling of water by man from one community to the next or one mouth to the next has created a need for standards by which the quality of the water can be judged at any point in time and place. The two basic criteria applied by the layman in judging water are usually that it must look good and that it must taste or smell good. No immediate consideration is given as to number and kind of bacteria present and their possible effect on human welfare. If after drinking the water there are no illnesses, it is generally assumed that the water is safe for human consumption. On the contrary, if illness follows, the water supply is often referred to as polluted; the meaning of which is still being debated around the world.

Originally, the word pollution was adapted from the Latin word *Pollutionem* meaning defilement. The Oxford English Dictionary, as early as the fourteenth century, cites examples for pollution as defilement of man, his beliefs or his symbols by physical, moral or spiritual contamination.

Examples of the usage of *pollution* or the verb *pollute* as we know it today with reference to physical and chemical contamination of terrestrial or aquatic environments were not given until late in the eighteenth century. And the term pollution did not become a common household word signifying contamination of water, air, and soil until mid-nineteenth century. Currently, it is considered somewhat of a magic word for those scientists seeking financial assistance or government support for their research projects.

Unfortunately, a satisfactory definition of pollution is still to be written. The United States Congressional Report No. 2021 defines pollution as AN IMPAIRMENT OF WATER QUALITY THAT INTERFERES WITH INTENDED USES OF WATER. What is pollution under one set of circumstances may not be in others. To man, green algal scum on lakes is pollution if he is interested in swimming; but, if he is a fisherman the same green algal scum might be looked at as food for fish and necessary for their survival. Ordinarily, dissolved oxygen in water is a sign of health and life; but, in steam boilers oxygen means serious corrosive problems and costly repairs. Not all toxic or poisonous substances are necessarily pollutants either. In time of war chlorine has been used as a lethal gas. However, chlorine when added properly to water supplies reduced the death rate for typhoid fever in United States from 32 per 100,000 in 1908 to less than one in a 100,000 in 1971. Another toxic substance, flourine, has resulted in as much as a 60 percent decrease in dental decay when properly applied to drinking water supplies.

What is Ife's Drinking Water Like?

The water available to the Ile-Ife area is supplied by the Ede-Oshogbo Filtration Plant of the Western Nigeria Water Corporation. The source of the water is the Erinle River upon which a dam has been placed to create an impoundment of approximately 15 acres with a maximum depth of 45 feet. The raw river water is treated chemically then settling and filtering occurs as it passes through a relatively modern water purification plant located on the Ede-Oshogbo road approximately 30 miles from Ile-Ife. The finished water is then pumped through underground pipes to towns and villages in the surrounding area which includes Ile-Ife.

When the water reaches the University, it enters a 10,000 gallon concrete reservoir located on Road 1 from which it is pumped through underground pipes to the entire campus. At the same time, this system is also pumping water into the large concrete storage tank on Hill No. 1 which, in case of an emergency, provides a reserve supply of water. The location of this reservoir high on Hill 1 helps to maintain the pressure on the entire water distribution system.

The water purification system in operation at the Ede-Oshogbo Plant should be quite capable of producing a water free of coliform bacteria and, thus, considered safe of drink without boiling. However, a few water samples were analyzed in the Bacteriology classes here at the University in January and February, 1972, and the results indicated that the quality of our drinking water left something to be desired. Since it is not fair to judge any product on such limited sampling, a Water Control Laboratory was organized by the Microbiology division of the Department of Biological Sciences in June, 1972. Residual chlorine tests were determined twice daily on campus. Coliform analyses on drinking water at three locations on the campus and one public tap in Ife were determined weekly; and, in addition, a preliminary survey was started to explore the effect that the effluent of the University sewage oxidation ponds might be having on the quality of water in the streams that are used by many of the nearby villages as a source of their water supply.

A regular sampling schedule was maintained from June 12 through September 18, 1972, with Technician O. W. Olorunfemi in charge and able part time assistance was rendered by laboratory workers, Diran Abimbola and Niyi Oketayo. Unfortunately, with the start of the 1972-73 academic session in September neither laboratory space nor personnel was available to continue the programme as initiated in June. However, the data collected did suggest several problems for further study, and currently seven Part III Microbiology students are doing research projects on various aspects of sanitation procedures and their possible effects on the health of the University community and the surrounding area. We are anxiously awaiting the results of such studies being carried out on topics as follows:

(1) Drinking Water Quality on the University of Ife Campus and in the City of Ife.................Ann Modupe Pinheiro

(2) Quality of Water in a Typical Yoruba Village.................
Mary Callista O. Lawanson

(3) A Bacteriological Study of the Effects of a Sewage Oxidation Pond Effluent on Stream Quality......Jonathan Gbadebo Ojo

(4) A study of the Algae of the University of Ife Sewage Oxidation Ponds....................Andrew Erhiruhoro Egbegbedia

(5) Performances of the Sewage Oxidation Ponds at the University of Ife..........................Ayodele Olusegun Oshodi

(6) The Effect of Sewage Pond Effluent on Local Streams at the University of Ife....................Olubiyi Akinsoji Akintobi

The Microbiology division of the Department of Biological Sciences is indebted to both Dr. A. A. Abiodun of Agricultural Engineering and Professor A. M. A. Imevbore, Head of the Department of Biological Sciences, for assistance and encouragement rendered to the students involved with chemical and physical aspects of the sewage oxidation pond studies. It is because of this kind of cooperation from people outside of Microbiology that we were able to accommodate eleven students working at Part III level to complete a degree with specialization in Microbiology during this academic year.

Samples collected between June 12 and September 18, 1972, revealed that the tap water collected in the staff housing area on campus failed to meet the safe drinking water standard at any time during the fifteen weeks sampled. In other words, 100 percent of the time the water would have to be considered unsafe to drink without boiling in the staff housing area. In the Microbiology laboratory, fourteen of the fifteen samples taken, or 93 percent, would be considered unsafe while in the town of Ife at the public tap near Singer Company twelve out of fourteen, or 86 percent, were found unsafe. The best quality of water found was in Fajuyi Hall collected from the refrigerated drinking water fountain where seven out of fifteen samples or 47 percent yielded coliform bacteria above the legal limit (Table II). It doesn't ordinarily seem conceivable that a drinking fountain should improve the quality of water necessarily but this in fact has happened as comparable water samples collected from the cold tap in the Fajuyi kitchen yielded results much higher and similar to other sampling stations on campus. The effect of the refrigerated drinking fountain on water quality is currently included in the research project of Ann Pinheiro.

The fact that the water in staff housing never met the legal limit for a safe drinking water is not as serious as it might first appear, for it is common practice for most staff members to filter and boil their drinking water. The more serious problem is how to insure the much larger student population of a safe drinking water supply when we know that they do not have filtering and boiling facilities available and in fact such a solution would hardly be practicable.

Our best control over the final quality of water is chemical treatment involving chlorine administered as a gas. The routine tests made for chlorine twice daily from June 12 through September 18 failed to show any evidence of a significant amount of chlorine in our water. It is ordinarily considered a good operational technique

TABLE II

Quality of Drinking Water at University of Ife and in Ile-Ife between June 12 and September 18, 1972

*Expressed as most probable number of Coliform Bacteria per 100 Milliters ***

Month	*STAFF Housing*	*Faculty of Agri-culture Room 30*	*Ile-Ife Singer Tap*	*Fajuyi Hall Drinking Fountain*	*Per-centage samples unsafe*
June 12	17	6.8	—	13	100%
,, 19	33	31	27	33	100%
,, 26	33	23	49	2.0	100%
July 3	33	4.5	23	0.0	75%
,, 10	14	6.8	17	12.0	100%
,, 17	4.5	2.0	2	0.0	75%
,, 24	2.0	0.0	4.5	0.0	50%
,, 31	7.8	2.0	13	0.0	75%
Aug. 7	6.8	7.8	7.8	2.0	100%
,, 14	33	4.5	13	0.0	75%
,, 21	4.5	2.0	11	0.0	75%
,, 28	79	49	33	0.0	75%
Sept. 4	2.0	4.5	0.0	0.0	50%
,, 11	4.5	4.5	4.5	4.5	100%
,, 18	13	2.0	0.0	2.0	75%
Percentage Samples Unsafe	$\frac{15}{15}$=100%	$\frac{14}{15}$=93%	$\frac{12}{14}$=86%	$\frac{7}{15}$=47%	—
Average M.P.N. Coliforms**	19	10	15	5	—

** Water is considered safe for human consumption when you have less than 1.0 coliform per 100 milliters.

to have a residual of chlorine in the amount of at least 1.0 part per million (PPM) in the water as it leaves the water treatment plant or storage facility. Our first alternative could be to request a larger dosage of chlorine at Ede-Oshogbo Water Treatment Plant so as to insure the water of having at least some residual chlorine when it reaches the University campus. However, the fact that our water goes into a storage tank where it may be retained for some-time before reaching the user complicates the problem. We are finding some evidence that significant amounts of chlorine can be found on occasions in the town of Ife at the public taps which would indicate that by using a storage tank on campus the chlorine could be dissipated before the water reaches the consumer.

A second alternative would be to install a chlorinator on the University of Ife campus and add chlorine to the water being supplied by the Western Nigeria Water Corporation. We would then have the application and the control of the chlorination process administered locally and not be subject to the many vicissitudes that might occur at the Ede-Oshogbo Plant or at any other points in between here and there.

Nature Versus Man

We will now leave the matter of water quality and turn over the coin and look at the other side where we have the problem of sewage disposal to contend with.

It is unfortunate that man is blamed for almost all the present day pollution problems. In fact, it has been made to appear that if nature is left alone, she would not defile herself. We need only to cite the Indian name "Green Bay" applied to the arm of water off of Lake Michigan. Obviously, this body of water was green with algae long before white man or the Green Bay Packers of football fame arrived on the scene in Wisconsin. Likewise, the present Missouri River was not named the "Big Muddy" by the Indians because of its clean and clear water. It must have been carrying many tons of earth each day down its course to the sea long before white man plowed the great plains and started raising wheat. There are springs on the Arkansas and Red Rivers in the United States that carry as much as 17 tons of salt per minute into these fresh water rivers. The Red Sea owes its color to a blue-green alga, *Trichodesmium erythraeum*, that grows as a benthic form at great depths and then becomes free-floating in such concentration as to color the water red. This same algae also occurs in the Vermillion Sea of Mexico and is responsible for its red color.

It would appear that nature in her various forms of activity can be a menance that often goes unrecognized and innocent of any deteriorating effects. Earth quakes, hurricanes, floods, droughts, erosion and volcanoes are but a few of the forces at work in the realm referred to as natural occurrences. Lakes, rivers and even oceans have been brought into being and also been made to age, die and disappear before man arrived on the scene. Even the dinosaur disappeared without any interference from man but this was also well before 1769 when James Watt fired the first big gun that started the Industrial Revolution with his invention of steam power.

Water pollution as we know it today had its beginning with the Industrial Revolution. When man hunted or herded his livestock on the land and grew only the crops necessary for his own survival, the disposal of wastes was never an acute problem. However, with the advances in agricultural methods in the eighteenth century, the productivity of men growing crops increased and paved the way for some to leave the land and begin other occupations. Discoveries and inventions along with the use of capital during this period led to the development of factories where the demand for manpower resulted in gainful employment and a new way of life when compared to the rural setting. This early movement of people to the cities increased throughout the Industrial Revolution and continues even today in many parts of the world.

The rapid growth of cities in England in the early nineteenth century resulted in large concentrations of people in areas with little or no community organization. In 1840, Sir Edwin Chadwick surveyed several of these cities and found water supply and waste disposal facilities almost indescribably foul. Cholera and Typhoid epidemics were commonplace. Some fourteen years later John Snow in London took a bold step and implicated the sewage polluted water in the Broad Street well as being related to the Cholera epidemic. This must be considered a bold venture as the Germ Theory of Infection had not been proposed as yet by Louis Pasteur. Furthermore, the causative agent for Cholera was not reported by Robert Koch until 1880. At about the same time Laveran, a French army surgeon, discovered the parasite responsible for causing Malaria. It should be emphasized here that with these discoveries Bacteriology was born and today the subject is still less than 100 years old.

Originally, the sewage systems in Europe and the United States were designed for the removal of storm and other drainage water only. The so-called sewers of Rome had very few house connections and were primarily designed for the removal of surface and underground waters. The human wastes were usually thrown out through windows and into the street where they may or may not have entered street drains. The discharge of human wastes into sewers was forbidden by law in London until 1815, in Boston until 1833, in Paris until 1880 and in Baltimore until very near the end of the century. Eventually, foul conditions developing in cities led to direct introduction of these wastes into sewers. Although the introduction of human wastes into sewers improved living conditions around houses, it led to foul conditions in rivers and streams and instead of solving the problem simply relocated it. It is reported that odours arising from the Thames river in 1858 and 1859 made life almost intolerable in London.

Conditions in American waters were not much better. The city of Chicago was taking its drinking water from Lake Michigan and at the same time disposing of its sewage in the same body of water. The construction of the Chicago drainage canal prevented sewage from entering Lake Michigan, but this action only diverted the sewage to the Illinois River which joins the Mississippi River and serves as the drinking water supply for the large metropolis of St. Louis, Missouri. As a result, litigation was started by the State of Missouri in 1900 claiming that sewage from Chicago was a hazard to the residents of St. Louis. Other litigation concerning this matter is still continuing even at this moment .

The Chicago drainage canal became known as "Bubbly Creek" with thick scum in places so firm that people could walk on it. While sanitary conditions in the cities of the United States did not become quite as intolerable as in England, it does not appear that the United States can claim much credit for their "healthier than thou" position. The fact that the Industrial Revolution came somewhat later in America and that many of the cities developed on larger waterways only delayed the inevitable problem that we now face and call polluition.

By way of preparation to combat pollution, representatives of both State and Federal Boards of Health in United States were sent to England and Europe to study waste disposal practices during the period from 1870 to 1880. It is a bit embarrassing to all mankind when we now learn that Mesopotamian empires of Assyria and Babylonia had reached levels of advancement that included flushed latrines in houses, laterals leading to sewers constructed of brick as early as 2500 B.C.

In Deuteronomy 23:12-13 you can read,

> Thou shalt have a place also without the camp, wither thou shalt go forth abroad; and thou shalt have a paddle upon thy weapon; and it shall be, when thou wilt ease thyself abroad, thou shalt dig therewith, and shalt turn back and cover that which cometh from thee.

Thus, with all of this historical information available, let us hope that the University of Ife will not defile her 14,000 acre campus by concentrating five to ten or more thousand people in a very limited area with no one too much concerned about the kind of "paddle" being employed.

I feel rather confident that the scattered villages that occupied the original campus of the University of Ife had relatively few water pollution problems to worry about as compared to those imposed by the current high density populations present in the many classrooms, hostels and staff housing areas. Fortunately, the technology is available to allow the University of Ife and all of Nigeria to sort out the methods most applicable to local situations and as a result avoid much of the costly trial and error procedures and mistakes experienced by other countries.

Pretty much the world over, the philosophy seems to be that anything "out-of-sight" is usually "out-of-mind". In this instance, the University sewage oxidation ponds are the case at point. They are well hidden from view in the bush beyond the Sports Stadium and below the Student Hostels. We have found that every few students and staff are aware of their existence and even fewer have ever taken the long walk to see them first hand. Yet, the outflow from these ponds enters the stream that crosses Ede road west of the campus. This stream then serves as a water supply for the several villages located along its course.

To establish a base line for the comparison of the efficiency of the oxidation ponds and their effect on stream water quality during low and high student populations on campus, a regular weekly sampling schedule was carried out from June 12, through September 18, 1972, when most students were not in residence on campus. The sampling stations selected were the bridge on Road I, near the entrance gate, and the bridge on Ede road west of the campus entrance. The stream passing under the bridge on Road I, is not affected by the outflow from the sewage oxidation ponds; but, it flows into a stream near the Ede road bridge that does carry the outflow from the ponds.

From the preliminary survey completed, the results seem to indicate that the sewage oxidation ponds are contributing significantly to the pollution and degradation of a natural waterway. The average coliform count on the stream passing under the Road I bridge without the addition of effluent from the sewage oxidation ponds was 4,941 over the fifteen week period. This same stream at Ede Road, after joining another stream carrying the out-flow from the oxidation ponds, averaged 33,360 coliforms (Table III). This represents a coliform population increase of nearly seven times the population found in the stream not receiving the effluent from the sewage ponds. Unfortunately, both sampling stations had averages well above 1,000 coliforms per 100 ml. which generally indicates mild pollution. In most natural waters the coliform count of 10,000 or above is considered as definite evidence of fresh sewage pollution and a MENACE TO HEALTH. Therefore, the stream receiving the sewage pond effluent with 33,360 coliforms is approaching heavy sewage pollution and should be considered definitely dangerous to health (Table I).

The current student research projects being carried out during November through February on the oxidation ponds and streams should show the effect of high student population on the efficiency of this system. Still another variable is the matter of rainfall with the June-September survey having been carried out during the rainy season and the current student projects restricted to the dry season. Thus, some of the relationships between high and low student populations on campus and the wet and dry season should be forthcoming with the completion of the Part III Microbiology student research projects in May of 1973.

TABLE III

Quality of Stream Water on the University of Ife Campus between June 12 and September 18, 1972 in Streams before and after the Entrance of Outflow from the Sewage Oxidation Ponds

DATE		*Stream at Road I bridge, no sewage pond outflow*	*Stream at Ede Road bridge with sewage pond outflow*
June	12	4,300	350,000
June	19	3,500	9,500
June	26	79	35,000
July	3	(240,000)†	5,400
July	10	1,300	2,400
July	17	1,700	4,600
July	24	4,900	13,000
July	31	7,900	13,000
Aug.	7	2,700	2,700
Aug.	14	2,700	4,900
Aug.	21	3,400	13,000
Aug.	28	13,000	7,900
Sept.	4	7,900	13,000
Sept.	11	7,900	13,000
Sept.	18	7,900	13,000
Average		4,941	33,360

† This sample was excluded because of the apparent influence of the many workmen repairing the bridge at the time of collection on July 3, 1972.

Sewage Treatment Methods

The first step in the conventional sewage treatment processes requires the mechanical separation of the solids from the liquids. Primary treatment then involves the solids only and is accomplished by diverting this material, which is chiefly organic, into a large air tight chamber called the digester. Here the anerobic bacteria and other microorganisms utilize the substance as food and produce a combustible gas as well as a harmless inert humus material called sludge. In Milwaukee, Wisconsin, this sludge is dried electrically, packaged and sold back to the people that produced it as an organic fertilizer.

Secondary treatment involves the 99.9 percent liquid portion of the sewage and it is accomplished by aerobic microorganisms that are cultured in a trickling filter or an activated sludg echamber. The effluent from the secondary treatment plant process may or may not be chlorinated before it is returned to the natural waterways. A properly operated sewage plant can produce an effluent water that is safe for human consumption.

Our campus sewage oxidation ponds are scientifically constructed lagoons with depths of three to five feet in which sunlight, oxygen, algae, bacteria, protozoa and other organisms interact to restore water to a quality equal to the effluent from a secondary treatment plant when properly supervised.

However, in a sewage lagoon, there is no separation of solids from liquids or primary and secondary treatment. Therefore, one must have careful control over the lagoons and not overload them or the balances of nature become upset and the purification process stops or becomes seriously impaired.

From the chemical, physical and bacteriological data collected so far, it appears obvious that immediate attention should be given to the manner in which the sewage is currently being treated. The effluent is not of good quality and it is polluting a natural waterway being used as a source of drinking water by people in several villages along the stream course.

The first and most obvious solution would be to construct more sewage lagoons. At most, this would only be a temporary solution for as the University population grows we will soon reach a point where the use of the sewage oxidation ponds is not the most efficient method to employ. In fact, we are already there.

The use of septic tanks in the staff housing areas, likewise, will soon need some careful consideration. Therefore, it would seem more reasonable to start planning for the conventional primary method of treating solids by the use of a digester. The existing lagoons could then be used for secondary treatment of the liquid portion of the sewage only. A marked improvement in the effluent entering the stream should result. The sludge that would become available following the primary treatment in the digester would be very valuable as an organic fertilizer to be used in campus landscaping or applied to field crops at the University Farm. The methane gas produced in the digester is highly combustible and could be used in the science laboratories and it also could serve as fuel to run engines for various purposes. For example, aerating the lagoons would increase their biological activity and general efficiency greatly.

What can the University of Ife do?

In light of the data available as of this date, it would appear that the University of Ife should proceed with the following:

(1) Establish a Water Control Laboratory on the campus where routine chemical tests for chlorine in the water should be determined hourly and coliform bacteria analyses should be performed at least once daily on drinking water supplied to the inhabitants of the campus community.

(2) If it is found that the drinking water being supplied to the University of Ife community is not consistently of good quality, then the cooperation of the Ede-Oshogbo Water Authority should be sought to keep closer control on their chlorination practices. If this fails then a chlorination system should be installed on the campus at the University of Ife and placed under the direct supervision of the Water Control Laboratory.

(3) Operation of the sewage oxidation ponds on campus should be placed under the direct supervision of the Water Control Laboratory for routine checks on the efficiency of operation.

(4) A primary method of sewage treatment should be added to the system as soon as possible. This would involve the construction of digesters or Imhoff tanks that would take care of the solid wastes and allow the liquids (99.9%) to be treated more efficiently by the present sewage oxidation ponds.

It is encouraging to be able to report that action has already been taken on the first recommendation. The administration of the University of Ife has made an initial sum of money available to the Department of Agricultural Engineering to establish a Sanitary Engineering Laboratory on campus. We trust that this represents the beginning of a better water supply and sewage disposal system for all concerned.

It is also a pleasant surprise to be able to report that as of January 8, 1973, residual chlorine has been found in significant amounts in the tap water of the Microbiology Laboratory and at residences in the staff housing area. As a result, it is hoped that improved water quality with respect to coliform bacteria will likewise follow, and that the University of Ife residents will soon be able to drink water from the tap without boiling and without fear of contamination.

By way of a summary, a *potable* water is one that can be used for drinking purposes with safety and satisfaction. The essential requirements of such a supply is that it shall be free of pathogenic bacteria. However, there are other demands which also must be met, namely:

(i) It must be relatively free of colour.

(ii) It must be relatively free of turbidity.

(iii) It must be free of tastes and odours.

(iv) It must have a relatively low temperature.

(v) It must be relatively free of hardness.

As for the term *sewage*, it appears quite likely that it will soon disappear from common usage and with it will go some of the stigma attached to its original meaning. This trend is reflected in the titles selected for "STANDARD METHODS" manuals published by the United States Public Health Service through twelve editions from 1899 to 1965.

"Standard Methods of Water Analysis" 1899, 1912, 1917, 1920, 1923.

"Standard Methods for the Examination of Water and Sewage" 1925, 1933, 1936, 1946.

"Standard Methods for the Examination of Water, Sewage and Industrial Waste" 1955.

"Standard Methods for the Examination of Water and Wastewater" 11th Ed., 1960; 12th Ed., 1965.

From the titles above it is significant to note that the term sewage does not even appear in the first five editions and it disappeared in 1960 with the eleventh edition. Thus, the "golden age" of sewage has presumably given way to wastewater which is a somewhat more palatable term.

In conclusion, water means different things to different people as evidenced by the compendium prepared by Professor K. M. Machenthun.

WATER IS.................. A NECESSITY FOR LIFE
A TRANSPORTER OF DISEASE
A SUSTAINER OF NAVIGATION
A COOLANT, CLEANSER, DILUENT
A MEDIUM FOR RECREATIONAL PURSUITS
A RESOURCE WITH FOOD FOR POPULATIONS
A POWER SOURCE TO HARNESS AND CONTROL
A SOURCE OF TRANQUIL, AESTHETIC ENJOYMENT
A REFUGE FOR BIOLOGICAL PESTS AND NUISANCES
A DEFILED PURVEYOR OF CIVILIZATION'S WASTES.

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