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Modelling and Construction of Acoagulation/Flocculation Tank for NDA Permanent Site

I Abdullahi[*1], U Tsoho[2], R Chukwumalume[3], Sagir Lawal[4]
[*1, 2, 3]Department of Civil Engineering, Nigerian Defence Academy, Kaduna
abuuthman67@yahoo.com

Abstract

A Flocculation system for water treatment facilities comprises of a flocculation tank having a plurality of baffle which divide the interior of the flocculation tank into a plurality of components. The baffle are arranged to provide inter compartmental openings between adjacent upstream and downstream compartment, which in turn are arranged to provide a serpentine flow path through the flocculation tank. A mechanical mixer is mounted in each compartment for supplementing the mixing energy provided by the serpentine flow, particularly during period of low water flow rates. The aim of this research work is to construct a model of a flocculation tank capable of contributing in the water treatment process to provide domestic water supply for NDA permanent site. The objective of construction of coagulation /flocculation chamber is to produce a settled water of low turbidity which in turn will allow reasonably long filter run using suitable coagulants type and required amount or dosage and achieving an effective floc formation.

Introduction

Water is very important for the survival of all living organism. It occupies almost 90% of materials making up the living organism. The use of water is increasing rapidly with our growing population. Already there are acute shortage of both surface and underground water in many part of the countries ,careless pollution and contamination of the streams ,lakes ,reservoir ,wells and other underground sources has greatly affect the quality of available water . This pollution is as a result of improper disposal of waste water both industrial and domestic. In areas where water occurs in abundant is satisfactory provision in term of quality and quantity, availability to users, cheapness and the effective disposal of in excess amount is always a challenging engineering and management problems, hence the supply of water anywhere and for whatever purpose is always a big project. Scientists began to recognize that specific diseases could be transmitted by water. Since that discovery, treatment to eliminate diseases causing micro-organism as dramatically reduced. Although water treatment processes has greatly improved the quality and safety of drinking water. Water can become contaminated with these organisms through surface runoff which contains animal waste, failure in septic sewer system and sewage treatment plant effluence. The primary process in surface water treatment is chemical clarification by coagulation, flocculation, and sedimentation. Lake and reservoir water has a more uniform year round quality and requires a lesser degree of treatment than river water. Natural purification results in the reduction of turbidity and coli form bacteria, and the elimination of day-to-day variations. On the other hand, algal growth cause increased turbidity and may produce difficult-to-remove tastes and odours. The choice of chemicals to coagulate the water for removal of turbidity depends on the character of the water and economic conditions. The most popular coagulant is alum (Alluminium sulphate). As a flocculation aid, the common auxiliary chemical is a synthetic polymer. Activated carbon is applied to remove taste and odor-producing compounds. Chlorine and fluoride are post treatment chemicals. Pre-chlorination may be used for disinfection of the raw water only if it does not result in formation of trihalo-methanes.(MIWR,2009)

Quality of Raw Water

Raw water is that which no treatment is applied .Improvement in raw water quality is noticeable purely as a result of retention of water in the reservoir. This is as a result natural settling of suspended solids. This is accompanied by marked reduction in pathogenic organisms.

Water Analyses

Various types of impurities present in water can be determined by water analyses. This analysis is done both for raw water as well as treated water or purified water. The examination of raw water will unable us to determine the outline or processes of water purification.

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Water analysis of purified water is done in order to know whether the degree of purification has reached the required standards or not. The following are the purposes of water analysis of raw water and purified water:

i. To classified the water with respect to general level or mineral constituents
ii. T o determine the degree of clarity and ascertain the nature of matter in suspension.
iii. T o determine the chemical and bacteriological pollution of water.
iv. To determine the level of organic purities.
v. To set the outlines of purification process and specify various stages in it.

The examination of water may be divided into:

(a) Physical examination and
(b) Chemical examination.

The Physical Examinations: These consist of**,**

i. Colour test
ii. Taste and odour test
iii. Temperature test
iv. Turbidity test
v. Conductivity measurement or test.

The chemical examination: These consists of ,

i. Total solid
ii. Chlorides
iii. Hardness
iv. P^h value
v. Dissolved gases.

Types of Impurities Found In Raw Water

Absolute pure water is rarely found in nature**.** The impurities occur in the progressively five stages above. Different methods of treatment as required for their removal or reduction to acceptable limits.

Suspended Solids:- These are solids particles which are commonly found in running water. Running water has the capacity to accumulate and transport solid matter of high density than stagnant water, the high the velocity of the running water the more particles picked up. This water is at their most turbid state, because of the increased velocity in the channels. Some example of suspended solids particles are algae, protozoa, bacteria,

Dissolved Solids:- These are soluble substance normally found to be associated particularly in ground water and sometimes in surface water. They could be calcium, magnesium, sodium, potassium, iron. These are normally combined with bicarbonates, sulphates, chlorides, nitrate, and other salts. Gases may be absorbed particularly carbon dioxide, oxygen, nitrogen and ammonia. Colloidal impurities are electrically charged. Due to this, the colloidal particles usually very small in size remain in constant motion and do not settle.

Treatment Required

Treatment of water is the process by which raw water intended for use by the public passed through certain stages to determine areas of possible contamination along the delivery time required because it provides results to prove that the water reaching the consumers is certified for human consumption by testing through the main approved water quality process involved in the treatment of raw water to acceptable standard. Full treatment of water for domestic purpose may comprise of the pre-treatment (which include screening, pre-chlorine, aeration and water storage). Algae control and straining coagulation, the addition of chemicals mixing, flocculation, settlement, filtration and disinfection.

Coagulation and Flocculation

Flocculation is the controlled motion or agitation of water which will assist in the formation of settle-able floc formation. Finer particles must be chemically coagulated to produce larger floc that is removable in subsequent settling and filtration processes. Coagulation and flocculation are sensitive to factors such as type and nature of turbidity producing

Substances, concentration of turbidity, type of coagulant and its dose, the rate of change of velocity per unit distance normal to a section, the pH of the water etc. Coagulation and flocculation are clarification method that works by using chemicals which course the suspended particles to attract and stick together so that the settle out of the water or stick to sand and other granules or a granular media filter. If the suspended solids in the water are fine or colloidal in size chemicals are often used to effect more complete removal of suspended matter. Flocculation is widely used in the treatment of water, industrial and municipal effluents to remove suspended solids quickly. It serves as a means of assisting in the removal of colloidal particles by causing them to form large aggregate through the addition of chemical reagents (flocculants). Flocculation may be accomplished using a variety of means including shortly rotating paddles flow through over and under baffle chamber and with the addition of a gas usually air. The flocculants that are widely used are aluminum sulphate, ferrous sulphate, and polyelectrolyte.

Common Flocculants Used

Commonly used metal coagulants in water treatment are (1) based on aluminums such as aluminum sulphate, sodium aluminates, potash alum, and ammonia alum, and (2) based on iron such as ferric sulphate, chlorinated ferrous sulphate, and ferric chloride. Aluminum sulphate is the most widely used coagulant. Synthetic polymers are used as coagulant aids to improve settling and toughness of floc.

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Jar tests are widely used to determine optimum chemical

Aluminum sulphate or Alum

This is the common and universal coagulant used in water works. It chemical composition is $Al_2(SO_4)18H_2O$. It requires the presence of alkalinity in water to form the floc. Much water has bicarbonate alkalinity naturally in them. When dissolved in water, aluminum sulphate tends to hydrolyzed into aluminum hydroxide as is evident from the following reactions:

$$Al_2(SO_4)18H_2O + 3Ca(HCO_3)_2 = 2Al(OH)_3 + 3CaSO4 + 18H_2O + 6CO_2$$

The aluminum hydroxide formed above is insoluble in water and is therefore a floc.

Ferrous sulphate and lime

Ferrous sulphate or copper can react with natural calcium bicarbonate alkalinity in water, but this is very much a delayed one =. Hence lime is used with ferrous sulphate.

$$FeSO_4.7H_2O + Ca(OH) = Fe(OH)_2 + CaSO_4 + 7H_2O$$

The ferrous hydroxides thus, formed, through an efficient floc is soon oxidized by dissolving oxygen in water and ferric hydroxide is formed

$$4Fe(OH)_2 + O_2 + 2H_2O = 4Fe(OH)_3$$

Polyelectrolyte

Polyelectrolyte's are high molecular weight, water soluble polymers. They are classified as anionic, cationic and non –ionic depending upon the charge the carry. Cationic polyelectrolyte can be used independently as effective coagulants while others are used as coagulant –aid along with alum etc. the cationic polyelectrolyte are available under certain trade name such as floccal N,Magnifloc972, Mogul 980 etc with polyacrylamides,it is important that the un-polymerized material should be absent. The amount of a polyelectrolyte used is very small in elation to the amount of the primary coagulate. The use of a polyelectrolyte not only boarded the P^H range over which satisfactory flocculation could occur, but may also reduce the quantity of primary coagulant required. The usual dosage is 1ppm

Purpose and Importance Of Coagulation And Flocculation

The purpose of coagulation and flocculation is to remove particulate impurities, especially non settle able solids (particularly collides) and color from the water being treated. Non settle able particles in water are removed by the use of coagulating chemical.

Literature Review

Long before the development of civilization, people recognize the difference in water quality. Water from various sources tasted sweet, salty, bitter, or sour. Somewhere hot while other were cold. Lerh et ai (1980) said that migrating tribes also knew that water at some cases ,springs or wells produced illness usually diarrhea. Through out the Middle East campaign censer's army had to boil water to ward off dysentery (Gass 1980) even earlier Hippocrates had warned his colleague to filter and boil water before drinking it. Some of worldwide plagues are epidemics were waterborne since sanitary protection of water supply facilities was practically none existent (Gass et at 1980)

Early Water Treatment

Although drinking water should be palatable and wholesome, to be palatable, water must be free from color, turbidity, test and odor, to be wholesome, water must be free from diseases against poisonous substances and excessive amount of minerals and organic matter. "Diseases producing organisms (pathogens) will be transmitted by water contaminated by faeces "(Bichi 1997). The first large municipal filtration system was built in Poughkeepsie in New York, United state in 1871; more sophisticated surface water treatment plants were constructed before world war one, using chlorination 0to control outbreak of typhoid fever.

Modern Water Treatment

Today municipal water treatment plants use a variety of processes which include screening, pre-chlorination and sedimentation. "Coagulation" can remove sediments, turbidity, color and organic matter .Softening reduces hardness "(Lerh et al 1980) clarification, filtration and oxidation are all use to remove very fine particles and manganese (Lehr, 1980)`reported that post chlorination is probably the final treatment process in most plant. He also observed that fluorides may be added to some supplies to protect children from tooth decay. There is still a wide range among final values of certain constituents in finished public water supplies. To aid coagulation and improve performance, coagulant and filters aids are used in filters prior to filtration or added to the filter media grains. An American water works association publication 1969 reveals that the addition polyelectrolyte as filter aid to "the filter influent has the same effect as decreasing the grain size or pore space " which increase the filter efficiency . Other factors like the P^H and temperature performance. The P^H value of water affects the coagulation process which plays a major role in filtration. The best coagulation results are usually obtained with alum when the P^H value is between 6.5 and 8.5. Until in the mid-20th century the design of treatment plants was handled exclusively by Civil Engineers and emphasis was placed on the hydraulic foundation and structural aspects of the design.

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A horizontal flow baffle channel flocculation basin was provided to ensure efficient agitation of the raw water after the addition of the coagulant. Although horizontal flow flocculating basin required very large area of land (which is very expensive in urban areas),it has several advantage over mechanical flocculation in the case of rural areas it requires no imported equipments and local materials and personnel. Hence it is preferred in developing countries. The design also favours sedimentation basin for more efficient treatment of large quantity of water .Also the scrapper helps on an efficient disposal of sludge without much waste of water. The simplicity in its structural design makes it far less costly. In order to achieve a high degree of treatment a slow sand filter is provided.

Coagulation and Flocculation

Coagulation: - The process by which colloid particles are destabilized is achieved mainly by neutralizing their electric charge, the products used for this neutralization is called a coagulant. In this process, very fine suspended solids and colloidal solid and particles with diameters of less than 0.01mm these include fine silts, for days, months or even years although individual particles cannot be seen with the naked eye. Their combined effect is often seen as color turbidity in the water. Those particles if not properly coagulated and flocculated they could adversely affect the clarity of water, but its taste and odor, as well as the effectiveness of chlorine disinfection. Coagulation works by eliminating the natural electric charge of the suspended particles so that they attract and stick to each other, the joining of the particles so that they will form large settle able particles is called flocculation. The large formed particles are called floc. The coagulation chemicals are added in a tank (often called a rapid mix tank or flash mixer) which typically has rotating paddles. Inmost treatment plants, the mixture remains in the tank for 10 to 30 seconds to ensure full mixing. The amount of coagulants that is added to the water varies widely due to the different source of water quality. One of the most common coagulant s used is aluminums sulphate sometimes called filter alum. Aluminum sulphate reacts with water to form flocs as aluminum hydroxide. Coagulation with aluminum compounds may leave a residue of aluminum in the finished water. This is normally about 0.1 to 0.15mg/l. It has been theorized that aluminum can be toxic to humans at high concentration. Iron (ii) sulphate or iron (iii) chloride are other common coagulants .Iron (iii) coagulants work over large P^H range than aluminum sulphate but are not effective with many source waters. Others benefits of iron (iii) are lower cost and in some cases slightly better removal of natural organic contaminants in some water. Coagulation with iron compounds typically leaves a residue of iron in the finished water. This may impart a slight taste in the water ,and may cause brownish stains or porcelain fixtures ,the trace levels of iron are not harmful to human and indeed provide a needed trace mineral because the taste and stains may lead to customer complaints, aluminum tend to be favored over iron for coagulation. Cationic and other polymer can also be used. They are often called coagulant aids used in conjunction with other inorganic coagulants. The long chains of positively charged polymers can help to strengthen the floc making it larger, faster settling and easier to filter out. The main advantages of polymer coagulants aids are that they do not need the water to be alkaline to work and they produce less settled water than other coagulant which can reduce operating costs. The draw backs of polymers are that they are expensive, can blind sand filters and filters and that often have a very narrow range of effective doses.

Flocculation: In flocculation, coagulants are used to stabilize the particles. The chosen coagulants and the raw water is slowly mixed in a large tank called a flocculation basin unlike a rapid mix tank, the flocculation paddles turn very slowly to minimize turbulence. If sedimentation is the intended clarification method, the principle involved is allow as many particles to collide with other particles as possible generating large and robust floc particles . Generally the retention time of a flocculation basin is at least 30 minutes with speed between 0.5 feet and 1.5feet per minute (15 to 45cm) minute. Flow rates less than 0.5ft/minute coarse undesirable floc settlement with the basin. An increasingly popular method of the floc removed is by (DAF) dissolve air flotation. A Proportion of clarified water, typical 5.10% of through put, is recycled and air is dissolved in it under pressure. This is injected into the bottom of the clarified tanks where tiny air bubbles are formed which attach themselves to the floc particles and float them to the surface. A sludge blanket is formed which is periodically removed using mechanical scrapers. T his method is very efficient at floc removal and reduces loading on filters, however it is unsuitable for water source with high concentration of sediment.

Chemical Coagulants Commonly Used

TABLE 1

NAME	FORMULAR
Ferric Alum	$Fe_2(SO_4)_2.Al_2(SO_4)_3.24H_2O$
Poly aluminum chloride	$Al_2(OH)_2$. $7Cl_3)15$
Ferric Chloride	$FeCl_3.6H_2O$
Calcium Hydroxide	$Ca(OH)_2$
Calcium Oxide	CaO

The most commonly used coagulants are ferric alum. However Poly Aluminums Chloride (PAC) is also used as coagulant. The advantages of PAC are:-

i. It gets properly dispensed
ii. It does not have any insoluble residue
iii. It does not affect the settling tanks
iv. It is more effective than alum
v. It requires less space (may be about 50%)

The disadvantage of P.A.C is that it is less effective in removal of color. Another common coagulant is alum ($AL_2(SO_4)_3$ $18H_2O$) which reacts with the alkalinity of water to form aluminum hydroxide floc. According to the following equation

$$AL_2(SO_4)_3\ 18H_2O + 3Ca(HCO_4)_2 \rightarrow 3CaSO_4 + 2Al(OH)_3 + 6CO_2 + 18H_2O$$

Aluminum sulphate + Calcium bicarbonate →Calcium sulphate +Aluminum hydroxide+ Carbon-dioxide +water

If the water does not contain the required alkanity it may be necessary to introduce lime (CaO) or soda ash (Na2CO3) in addition to alum to get proper flocculation.

Selection of Coagulants

Coagulation is a physical and chemical reaction occurring between the alkanity of the water and the coagulant added to the water, which result in the formation of insoluble floc. The most important consideration is the selection of the proper type and amount of coagulants chemical to be added to the water to be treated. Overloading as well as under dosing of coagulants may lead to reduced solids removal efficiency. This condition may be corrected by carefully performing jar test and verifying process performance after making any change in the process of the coagulation process.

JAR Test

The jar test has been and is still the most widely used method employed to evaluate the coagulation process and to aid the plant operation in optimizing the coagulation, flocculation and clarification process. From the turbidity values of the settled water, settling velocity distribution curves can be drwn.These curves have been found to correlate well with the plant operating data and yield useful information in evaluating pretreatment, such as optimizing of velocity gradient, agitation and flocculation, P^H, coagulation dosage and coagulant solution strength. Such curves cannot be generated and are relevant in the plant for which the data have been collected through the jar tests.

Tank Description

The flocculation tank is a rectangular tank that can be constructed of poured concrete, it consist of three section of all the end baffled flow each section was constructed with downward bed slope of 1:40 each section has a vertical drop of about 4.8” so that the beginning of section one is about 14.4” higher in elevation than the end of the third section. The slope was installed to counter balance head loss and was chosen in an attempt to maintain a constant water depth of all points on the tank. A space is left at the bottom of the baffle in the second channel to create a scouring section which might help to keep particles from settling. The outlet to the sedimentation tank consist of simple connection channel with no pipe or weir ,so that the surface water in both the flocculation and sedimentation tank are the same. Lastly an access way divide the first and second section approximately equal in width, so that the operator can easily walk along the tank clean/adjust baffle.

Interaction with Sedimentation and Filtration

The process of coagulation and flocculation are required to precondition or prepare non settle-able particles present in the raw water for removal by sedimentation and filtration. Small particles (particularly colloid), without proper coagulation and flocculation are too light to settle out and will not be trapped during filtration process. Since the purpose of coagulation – flocculation is to produce particles removal, the effectiveness of the sedimentation and filtration process as well as overall performance ,depends upon successful coagulation =flocculation

Sludge Handling

a. Sludge characteristics

Water treatment sludge is typically alum sludge, with solid concentration varying from 0.25 to 10% when removed from a basin. In gravity flow sludge removal system, the solid concentration should be limited to about 3%. If the sludge are to be pumped, solid concentration as high as 10% can be readily transported. In the horizontal flow sedimentation basins preceded by coagulation and flocculation over 50% of the floc will settle out in the first third of the basin length. Operationally, this must be considered when establishing the frequency of the operation of sludge removal equipment.

b. Sludge removal system.

Sludge which accumulates on the bottom of the sedimentation basin must be removed periodically for the following reason.

i. To prevent interference with the settling process (such as re-suspension of solid due to scouring).
ii. To prevent the sludge from becoming septic or providing an environment for the growth of micro-organisms that create taste and odor problem.

iii. To prevent excessive reduction in the cross-sectional area of the basin (reduction of detention time)

In large –scale plants, sludge is normally removed on an intermittent basin with the aid of mechanical sludge removal equipment. However, in small plants with low solid loading, manual sludge removal may be more cost effective. In manually cleaned basins, the sludge is allowed to accumulate until it reduces settled water quality. High level of sludge reduces the detention time and floc carried over to the filters. The basins are then dewatered (drained), most of the sludge is removed by stationary or portable pumps, and the remaining sludge is removing with squeegees and hoses. Basin floors are usually sloped towards a drain to help sludge removal. The frequency of shut down for cleaning will vary from several months to a year or more, depending on source water quality (amount of suspended matter in the water) ., In large plants, a variety of mechanical devices can be used to remove sludge including,

-Mechanical rakes
-Drag-chain and flight
-Travelling bridge

Circular or square basin is usually equipped with rotating sludge rakes. Basin floors are sloped towards the centre and the sludge rakes progressively push the sludge down towards a centre outlet. In rectangular basins, the simplest sludge removal mechanism in the chain and flight system.

Safety Consideration

In the coagulation –flocculation process, the operator will be exposed to a number of hazards such as:

i. Electrical equipment
ii. Rotating mechanical equipment
iii. Water treatment chemicals
iv. Laboratory reagents(chemicals)
v. Slippery surfaces caused by certain chemicals flooding.

Confined spaces and underground structure such as valve or pump vaults (toxic and explosives gases, insufficient oxygen) strict and constant attention must be given to safety procedures the operator must be familiar with general first aid practices such as mouth to mouth resuscitation, treatment of common physical injuries, and first aid for chemical exposure (chlorine). The followings are some special safety precaution applicable to the coagulation –flocculation process.

1. Most dry chemicals can irritate eyes, skin and mucous membrane –dry-chemical feeder should be equipped with dust control equipment, protective clothing, goggles and a respirator should be worn when the chemicals are being handled.
2. Dry alum and quicklime when mixed together create tremendous heat, if the temperature should reach 1, 100^{O}f(593^{O}c), highly explosive hydrogen gas will be released; these and other chemicals should be stored and used in a manner that will prevent improper mixing.

Methods of Feeding Coagulants

There are two methods of feeding coagulants to water

a. Dry feeding
b. Wet feeding

Dry feeding is the simple operation and requires relatively less space for its work. The feeding machines are also cheaper. However, control of dose is difficult. The dosage in the wet feeding equipment can be adjusted more readily and can be easily controlled by means of automatic devices however the chemicals which are corrosive in nature create problem in wet feeding.

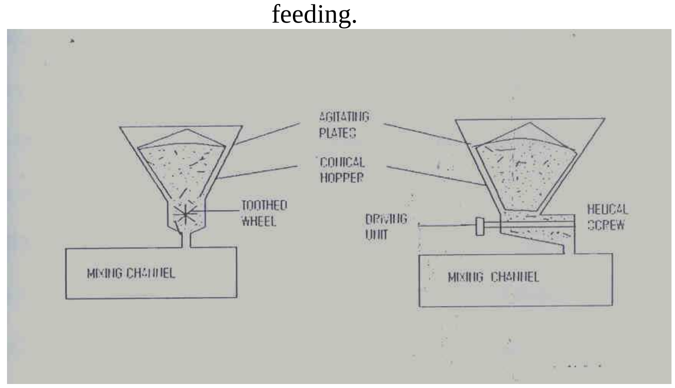

FIG1

(a)By toothed wheel
(b) By helical screw

Dry Feeding

The diagram above shows two common devices used for dry feeding. In each case, the coagulant, in a powdered form is kept in the tank with hopper bottom. In order to prevent the arching of the chemical, agitating plates are placed inside the tank

In (a) the feeding is regulated by the speed of the toothed wheel which is connected to the venture device in the raw water pipe.

In (b) the feeding is regulated by the helical screw. The drive unit of the helical screw is governed by the venture device in the raw water pipe..

Wet Feeding

In the case of wet feeding, the solution of the coagulant of the required strength is prepared and stored in a tank from where it is allowed to fall in the channel. The quantity of the mixture falling in the water channel is regulated in proportion to the quantity of flow. Wet feeding can be done by conical plug and float. The solution of the coagulant is stored in a contact head feeding tank. The feeding of the coagulant to raw water channel is regulated through the conical plug which is govern by the movement of the pulley attached to the rod which in turns is rotated by the rock and pinion arrangement.

Mixing Devices

The mixing process not only mingles the coagulant with the water but has a very great effect upon the formation of the floc. It is usual to introduce the chemical at some part of high turbulence in the water. After the dose of the chemical is added to the raw water, thorough mixing is provided by the following method:

1. Centrifugal Pump

In most cases, centrifugal pump is used to raise the raw water settling tank. The required dose of the chemical therefore can be added to the suction line of the pump. When water is fed with the coagulant passes through the impeller of the pump, mixing is accomplished by the agitation. However, after the water comes out, some gentle agitation is required to get good result and accelerate coagulant and sedimentation.

2. Compressed Air Agitation

In this method the raw water fed with coagulant is agitated vigorously by diffusing compressed air from the bottom of the mixing basins.

3. Mixing Basin Weith Baffle Walls

In the horizontal or "round type" basin, the water flows horizontally for a short distance makes a complete turn and continues back and forth around the ends of the baffles. This causes turbulence and hence the mixing, another type, known as the vertical or "over and under " type and in smaller plants has vertically hanging baffle walls due to which are not used up and down. Mixing basin with baffle walls are not used now because of high head losses and vibrations in the velocities.

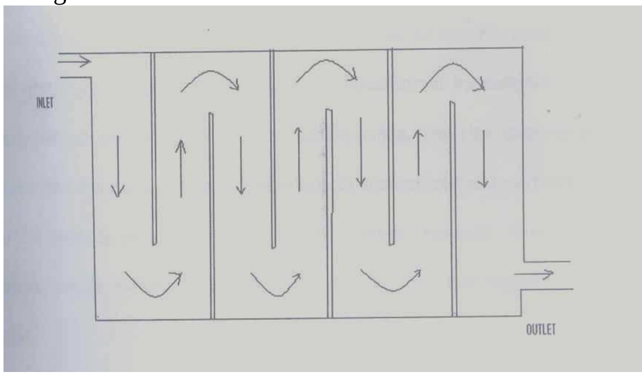

Figure 2

Methodology/Analysis of Result

The method established for the study involved the collection of samples from the river for the study area and these sample were collected from the lower part of the river valley. Interview was carried out with the respective personnel of the NDA permanent site and other close by the inhabitants regarding the contamination rate and how it has been affected by farming close by.

Data Collection

The necessary data obtained from the analysis carried out on the sample is very essential in which it will provide the reliable results to be compared with those stipulated World Health Organization (WHO) allowable or permissible for any water to have before recommendation for usage. The presentations of data obtained from the chemical analysis are illustrated in table below.

Table 2
Chemical analysis of raw war sampled from river gora

S/NO	TEST	RESULT
1	Turbidity	5.44NTU
2	P^H	7.2
3	Chloride	49.98mg/l
4	Total Alkalinity	26.00mg/l
5	Total dissolved Solids	34.1mg/l
6	Total Iron	0.2mg/l
7	Lead	-
8	Total Suspended Solid	15.3mg/l
9	Hardness	22.52mg/l
10	Acidity	8.2mg/l

Table 3.Who Water Standards (International Standard For Drinking Water)

S/NO	TEST	PERMISSIBLE VALUE	EXCESSIVE VALUE
1	Turbidity	5	25
2	P^H	7.0-8.5	<6.5 or <9.2
3	Chloride	200	600
4	Total Alkalinity	-	-
5	Total dissolved Solids	500	1500
6	Total Iron	-	-
7	Lead	-	-
8	Total Suspended Solid	-	-
9	Hardness	30	500
10	Acidity	-	-

Population Study

In population estimation of a given community, there are various method that can be adopted, these include**:**

i. Geometric progression, which is mostly used in community where growth rate can be determined through birth rate.
ii. Arithmetic means method
iii. Ratio and correlation method
iv. Comparative method

Development plan method is used in this project to estimate the cadet expected population in the 70 years .It showed that cadet's population in NDA does not increase geometrically but based on NDA TRAINING PLAN.

Estimate of Stabilized Population of NDA

Any water supply and distribution scheme must be planned to serve the present as well as the future need of this Academy hence stabilized population of the NDA must be assessed . While designing any treatment plant for the population of the Nigerian Defence Academy is governed by:

i. Admission pattern
ii. Staff employment pattern
iii. Deployment officer and soldier to NDA
iv. Accommodation policy.

In an institution like NDA population projection is determined by development plan. The data collected from various units of NDA review their present population as follows:

Table 4. Data collected for population

Branch	Population
a. Logistic	
i. Soldiers	1,259
ii. Officers	211
B. Registry civilian staff	1,640
c. Cadet brigade	1,138
Total	4,248

In this project the design is based on the population of resident of the NDA hence, considering the size of family to be 1x6 person by average 65% staff were not accommodated is

1,640x6x (65/100) =6396

Total number of staff accommodated**=9840-6396**

=3444

Total number of soldiers **=1470x6=8820**

Including cadet's population**: 1444+8820+1138=13402**

Approximately, (**14000)** persons for the purpose of the project.

It will be designed to serve1400 person at the design period dur to the fact that NDA Population does not increased geometrically; the number of regular course cadet's admitted into NDA within 25 years from 1980 to 2005 =1321(source NDA year book 40th Anniversary)

Discussion of Result

(i). Turbidity: The value obtained from the analysis is 5.44NTU, according to the WHO standard the value ranges between 0-5NTU the value obtained is slightly high .What this implies, is that you will need more alum to settle this water before any further treatment it should be noted however that the difference is not much and so it is tolerable.

(ii). P^H : The P^H value obtained is 7.2 the standard value ranges between 6.5-8.4. This is an indication that the water available is within the P^H range that is safe and manageable.

(iii) CHLORIDE: The value of chloride obtained is 49.98 the standard tolerable is up to 250mg/l, therefore the value obtained is quite minimal. However the indication of chloride in water shows faecaler569g contamination. This from observation comes from cattle reared around the water shed. The cattle depend on this stream for watering and occasionally defecate directly into the stream system. This accounts for this faecal pollution that showed slightly in the result since this value is negligible.

(iv) TOTAL ALKANITY: This value obtained up to 20mg/l bears out the P^H that this water is slightly alkaline in nature as a a result we can conveniently say that the water is not only safe for human consumption but can also be conveyed by steel pipe and its steels pipe that can suitable for such rocky or hard ground prevalent in the area.

(v) TOTAL DISSOLVED SOLID: The value obtained is 32.1mg/l the total tolerable standard is up to 500m/l this indication that, the dissolved solid is not much in the water system. The hard water under- layer insoluble geological formations of the area. For this reason the filter will be under much pressure such that it could flow down the process of filtration.

(vi) TOTAL SUSPENDED SOLID: The value obtained is 15.3mg/l this is equally an indication that there is no much solids in suspension the level of suspended solids is responsible for the clarity of the water sample .Chemical required for settling materials in suspension will not be much in this case.

(vii) HARDNESS: 22.52mg/l obtained indicate that the water is soft and not hard, in must cases surface water not passing over carbonate formation are not usually hard. The standard value ranges from 30-500mg/l. hard water normally don't form lather at once with soap. When the sample was tested using soap it formed lather readily with soap.

(viii) TOTAL IRON: The value obtained or total iron is 0.2mg/l this is below the standard value which ranges between 0.3-1.0mg/l this indicate that this water does not necessararily need aeration to precipitate it out of water. It is safe for both domestic and industrial consumption.

(ix) ACIDITY: The acidity value is first`8.2mg/l this indication that this water is slightly acidic .This is due to H+ present in the water sample. This has no effect on the system.

Water Demand Estimate

The estimate gives the total quantity of water that will be required by the community at the design period. The NDA water demand is determined by the following factors:

a. Present population projected estimate at the end of the design period, using population projection.
b. Rate water demand per capital per dy the population projected estimate carried out in the master plan of the NDA permanent site ,the environment consultant group(ECG) estimated 1500 people at the end of the design period. The rate of water demand per capital per day is approximately 205lpcd.

Therefore 14000x205=2870000lpcd.
Which is =2870m^3/day
=2870/24x60x60=0.0330m^3/day

Material Use for Construction

The tank can be constructed of concrete; the baffles can be constructed out of corrugated PVC roofing materials and ½" inside diameter PVC piping or wood material of at least ¼ " thick. The corrugated PVC roofing material has so many advantages which are:

a. Plastic can be acquired cheaply relative to wood.PVC baffle were easy to construct, light in weight and installed more easily and rapidly than wood but plastic baffles might not be sturdy enough.
b. Wood can be chosen for its strength and it would be safe for drinking water application. Wood baffles is easy to construct but difficult to install and once installed they were sturdy robust. But its disadvantage is that it is relatively expensive and not readily available. Wood would rot in time and have to be replaced.

Design Data

The maximum flow rate (Qmax) =**0.0330m^3/day is used for the design.**

Velocity: Velocity rate of 0.6-0.8m/s (Met caff 1982) is employed to ensure self cleaning we assume velocity of 0.6m/s

Design of Inlet Pipe

(Inlet pipe)Qmax=VA but A= Qmax/V, where A=cross-sectional area of the pipe, V=the velocity.

A= (0.0033 m^3/S)/ (0.65m/S)=0.0507m^2 .Since the pipe is circular, the area A=ΠD^2 /4, then D^2=4A/Π

D= (√4X5.07X10^{-2}/3.142), therefore D=2.54x10^{-1}

Flocculator Design

Assume time of flocculation 30min.(Ray and Joseph 1972). Velocity gradient at entry in the first channel G_1=75s^{-1}, Velocity gradient in the second channel G_2=35s^{-1} and Velocity gradient in the third channel G_3=15s^{-1}

Total volume of flocculator
VT=Q_Dt
= (2870x30)/(24x60)=59.79m^3

Effective width of flocculator
Wg=V/(L+H),Let depth=30m(Met caff 1982).L=6.4m
Wg =(59.79)/(6.4x3)=3.1m

Width of each section
Ws=3.1/3=1.0

For water at 20^{o}c, U=1.01X10^{-3} Kg/m/s, P=998.2kg/m^3

CHANNEL ONE
G=75s$^{-1,T}$=10m

Number of baffles in the channel
N= {(2ut)/ (Px (1.44+F)x(HLG)^2/(Q)}$^{1/3}$, where f=0.3 for resistant decay timber
= {(2x1.01x10^{-3}x10x60)/ (998.2x (1.44+0.3) x (3x6.4x75)^2/ (0.033)} $^{1/3}$
=110baffles

Spacing between baffles
S_1=6.4/110=0.06m

Head loss in the flocculating system
H= (utxG^2)/Pg
=(1.01x10^{-3}x10x60x75^2)998.2x9.81
=0.35m

Distance between the end wall and the baffle
Dc_1=1.5x0.1=0.15m

CHANNEL TWO
G_2=35s$^{-1,}$ T=10min
Number of baffles== **{(2x1.01x10^{-3}x10x60)/ (998.2x (1.44+0.3) x (3x6.4x35)^2/ (0.033)} $^{1/3}$**
=66baffles

Spacing between baffles
S_2=6.4/66=0.09m

Head loss between the flocculating systems
H= (utxG^2)/Pg
= (1.01x10^{-3}x10x60x35^2)998.2x9.81
=0.08m

Distance between the end wall and the baffle
Dc_2=1.5x0.09=1.14m

CHANNEL THREE
G_2=15s$^{-1,}$ T=10min
Number of baffles **= {(2x1.01x10^{-3}x10x60)/ (998.2x (1.44+0.3) x (3x6.4x15)^2/ (0.033)} $^{1/3}$**

=38baffles

Spacing between baffles

S_3=6.4/38=0.17m

Head loss in the flocculating systems

H= $(utxG^2)/Pg$

= $(1.01x10^{-3}x10x60x15^2)998.2x9.81$

=0.01m

Distance between the end wall and the baffle

Dc_3=1.5x0.17=0.26m

Conclusion

It will be helpful to see more case studies of actual plants, what they were designed to accomplish, the condition they were designed for and an evaluation of their effectiveness.

Recommendation

For any meaningful design, its implementation may entrance the level of its beneficial use. Although this research is a clear guidance of what is actually expected when undertaking such a vital project in the area. Water in most cases when supplied free to people they tent not to prevent wasteful usage therefore there is a need to charge water rate after construction work has been completed. If possible the use of meter should be adopted.

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