DESIGN OF A GRAVITATIONAL DRIP IRRIGATION SYSTEM

A TECHNICAL REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR REGISTRATION OF COREN

BY

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CERTIFICATION

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ABSTRACT

The design and cost analysis of gravitational drip irrigation system was carried out in the Department of Agricultural Engineering Faculty of Technology University of Ibadan. This irrigation system was designed to suit farmlands not more than one hectare for small-scale farmers to irrigate vegetable crops. Before the design proper, preliminary studies were carried out and climatological data were collected, which was used to determine the rate of crop evapotranspiration used for the system's design i.e. 4.56mm/day for Ibadan climatic zone. The system has 100 laterals each of which is 50m long with each lateral having pressure-compensating emitters to distribute water and the mainline is also 100m long. A model of the gravitational drip irrigation system was designed and tested. The test carried out on the model system shows that it can deliver 2.1-liter/ hour of water with an operating head of 0.969m and the overall system's efficiency was found to be 94%. The efficiency of the system coupled with the installation and cost analysis shows that the system can be acquired and maintained by peasant farmers and still performs creditably well, when compared to the conventional drip irrigation system.

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CHAPTER ONE

1.0: INTRODUCTION

Rainfall is critical in particular because it replenishes the ground water, which plants use. It varies from region to region i.e. desert receives less than 250mm of rainfall and equatorial/tropical receives more than 2000mm of rainfall (Microsoft, 2001). The consequence of rainfall variation is that it affect's planting throughout the year. To produce the required food crops needed to feed the teaming population, a means of providing water at the right time and quantity other than natural precipitation is therefore inevitable.

This was what led to the use of surface water from the streams, rivers and lakes by the earliest society and from dams, canals and pumping stations in recent times to supplement the moisture needed for plant growth. This process is referred to as irrigation. According to Ogedengbe (2003b), irrigation is primarily the artificial application of water to the soil to sustain plant growth. He explains further that it might also be used for purposes such as: to remove excess soluble salt from the soil, to soften hardpan during tillage operation and to reduce the effect of soil piping.

Irrigation has greatly impacted on the amount of cultivated land and hence the increase in food production throughout the world (see Figure 1). 15% of all the land under cultivation is irrigated but often produces over twice the yield of non-irrigated field (Microsoft, 2001).

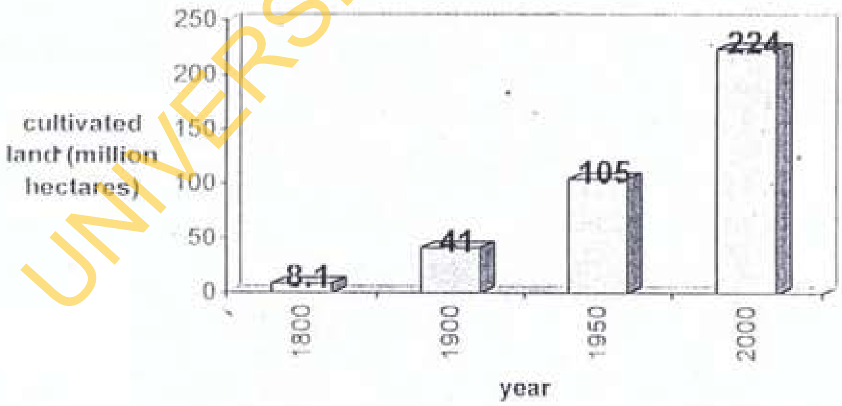

figure 1: a chart showing the impact of irrigation on cultivated land in the world.

Undoubtedly, irrigation has substantial advantage over rain fed farming and these include: higher gross yield per hectare, food production under severe condition of water supply, employment generation, and decrease in poverty and increase in foreign exchange.
However, no system can be perfect so irrigation is faced with some huge challenges which include: the accumulation of salt in the top soil which stunt plant growth, high initial investment in water supply, delivery systems and land preparation and the need of trained personnel that is proficient in setting up and maintaining irrigation systems. To conserve water and improve crop yield has been a major challenge in irrigation practice. Johan (2001) in his article published in land and water international, pointed out that:

"55% of the world population would be facing water scarcity problem by 2025".

This is because, of the estimated annual human requirement, larger volume of water is needed to produce food (about 90% is needed to support plant growth) thus leaving a smaller volume for human other needs. The rising cost of energy, scarcity of goods, land, water and increasing demand for agricultural products made the search for new knowledge on how to improve the efficiency of irrigation systems and the imperative to disseminate and apply the knowledge gained to date more urgent than ever (Stewart and Wielson, 1990). Science and technology has been able to break new grounds with a view to solving this problem through **drip irrigation.** This system takes into account the efficient use of water, which is indicated by its higher efficiency over the other conventional irrigation systems i.e. 95 %, 75 % and 45% for drip, sprinkler and surface irrigation respectively. For agriculture to sustain/supply the food requirement for the ever-increasing world population and with a view to conserve water for other domestic use, then an irrigation system with high rate of water use efficiency is worth considering

1.1: OBJECTIVES OF THE PROJECT

(1) To design cost effective gravitational drip irrigation system as an alternative to a pump drip irrigation system using available materials.

(2) To determine the efficiency of the system model.

CHAPTER TWO

2.0: LITERATURE REVIEW

The dependence of the human race on irrigation can be traced to some biblical reference and the history of the emergence and development of some civilization. (Schwab et al. 1993). According to historical records the Egyptians were the first to use irrigation along the Nile River about 5000 B.C. The Sumerians, as early as 2400 B.C used irrigation to water field in the Southern Mesopotamia (now Southern Iraq). The Chinese and Indians started using irrigation by 2200 and 1000 B.C The Peruvians and the Native Americans also used irrigation before the time of Christ. (Microsoft, 2001).

The remains of ancient water conveyance structure and irrigation systems were evidences that irrigation has been practiced since prehistoric times. (Schwab et al. 1993). The Egyptian Shadoof; Archimedes's screw and the Persian wheel are some of the devices used for lifting water from streams to irrigation fields in the past. (Microsoft, 2001). As at 1986 about 2/3 of the world's most irrigated land is in five countries namely: India, China, Soviet Union, United States and Pakistan. (Schwab et al, 1993).

Irrigation began in Africa (Egypt) when canals were constructed and used to direct water from the Nile River to farmland. Before the European colonial rule there already existed a significant African tradition of water management for irrigation i.e. in the east African rift there are extensive pre-colonial agricultural gravity fed irrigation system and in sub-Saharan Africa (Zimbabwe), Dambos (small valley wetlands, which retain moisture to within 2-3 meters of the soil surface) were used for irrigation (Cosgrove and Petts, 1990). The two most irrigated areas in Africa are Egypt and Sudan accounting for about half of the irrigated area while Nigeria and Madagascar also accounts for about 20% of the irrigated land. About 0.6 million hectares of land in Africa was under irrigation annually during the 18th century and about 98.6% of cropped land area was under organized irrigation (medium/large scale) during the same period. Development of irrigation in Africa was quite uneven unlike other parts of the world like Asia i.e. Africa has 10 times of land India has but in comparison India irrigate nearly 5 times as much land (Ogedengbe, 2003a). The level of irrigated agriculture in Nigeria has increased (see Table 2.1) and of the total irrigated area, more than 80% is under surface irrigation (Yoder and Thurston, 1990).

Table 2.1: Statistics of Irrigated Agriculture in Nigeria.

Total land area	98.3 million hectares
Cultivable area	73 million hectares
Crop coverage	5 million hectares
Irrigated area (1950)	120,000 hectares
Irrigated area (1970)	800,000 hectares
Irrigated area (2001)	0.9 million hectares
Area under modern irrigation (2001)	100,300 hectares

Source: Ogedengbe (2003a) and U.S Library of Congress (2003)

The northern region government in 1949 established the first irrigation agency. From 1972 to 1974,there was a severe Sahel drought that made the Federal and State Government to expend a large sum of money on irrigation. The ministry of water resources was established in 1975 and in 1976 eleven water basin development authorities were created. The south Chad and the Bakolori irrigation project in Borno and Sokoto state are some of the major irrigation project. The Ogun-Osun, Benin-Owena river basin development authorities were among the eleven river basin development authority created in 1975 (U.S Library of Congress, 2003). Nigeria with its large area of cultivable land and with a meager fraction of it under irrigation produces about 20-25% of the value of the nation's agricultural output from irrigated land (Ogedengbe 2003a).

2.1: MICRO (TRICKLE) IRRIGATION SYSTEM

Trickle irrigation is the slow and steady application of water either directly onto the land surface or into the root zone of the plant. This system works on the principle that only the part of the root- zone of the crop (rather than the entire land surface) is irrigated so as to maintain optimum water level at the root-zone (James, 1993).

Research on trickle irrigation first began in Germany about 1860. In the 1940's it was introduced to England. With Increase in the availability of plastic pipes and development of emitters in Israel (in the 1950's), it has since become an important method of irrigation in Israel, Japan, Europe, Mexico and America (Schwab et al. 1993).

Jess stryker's indicated that while the efficiency of sprinkler irrigation system is above 75% that of drip system is typically 90% and above, hence making it the most efficient irrigation system. The benefits of drip irrigation system include the following:

- There is improved crop yield from a drip-irrigated land as compared to the use of other irrigation methods.
- It has higher use, application and conveyance efficiency.
- It operates under lower pressure and hence requires less energy.
- Saline water could be used to irrigate through drip system without plant damage.
- It controls weeds and reduces pest and diseases due to partial wetting of the root zone
- It requires less labour and may be fully automated.
- Fertilizer and pesticide can be incorporated into the system and its use is minimized.

The major disadvantages of drip irrigation are as follows:

- The initial cost and requirement are high
- There is high tendency of the system to clog due to the settling of suspended particulate material.
- There is limitation of crop root development to the wetted portion.
- Salt problem may occur because only a small portion of the root-zone is wet.

American Society of Agricultural Engineer (ASAE) classify trickle irrigation as follows:

- **SUB-SURFACE IRRIGATION:** It involves the use of point source emitters to apply water below the ground surface. The plants make use of the water through capillary action.
- **SPRAY IRRIGATION:** It makes use of small sprinkler like device often called micro-sprinklers to spray water as a mist over the land surface. They are less likely to clog compared to sub-surface and drip irrigation systems. Loss due to wind drift and evaporation are however very high with this type of system.
- **BUBBLER IRRIGATION:** With this method water is added to the soil as a small stream. Water is applied through a tube attached to the lateral and it may be as large as 10

mm. They are less susceptible to clogging due to its large diameter and higher water discharge rate. Small basin may be constructed to control or contain the water.

- **DRIP IRRIGATION:** It was first developed in Israel less than 35 yeas ago and since then it has been disseminated to different part of the world with great success (Ogedengbe, 2003a). It is the steady and intermittent supply of water to a fraction of soil. It could be applied at single point on land through emitters or as a line source from closely spaced emitters or tubes. At this emitting points water is released at a rate that does not exceed the soils infiltration capacity, thereby penetrating without ponding. Discharge rate for point source and line source emitters are less than 12 L/h and 12 L/h/m respectively (A.S.A.E, 1987).

2.2: BASIC COMPONENTS OF A DRIP IRRIGATION SYSTEM

A drip irrigation system consists essentially of a main line, submain, lateral, and emitters. The ancillary components include a valve, pressure regulator, filters, pressure gauge, fertilizer application component, backflow preventer and end cap (Michael, 1999).

- **MAINLINE AND SUBMAIN:** The pipe that conveys water from the water source to the sub main is the mainline and the sub main conveys water from the mainline to the laterals. Mainline and sub main are normally made of polyvinyl chloride tubes but asbestos-cement pipe is occasionally used for main line. All main line and submain should be provided with a manual or solenoid activated valve at it's upstream and downstream to provide on and of service for isolation purpose and periodic flushing.
- **LATERAL:** It is the pipe, which actually conveys the water that would be distributed onto the field and emitters are connected to it. It is made from black polyvinyl chloride tubes.
- **EMITTER:** It is that part of the drip system that actually deliver water to plant root-zone. Generally, it has smaller passages for discharging water and is prone to physical, chemical and biologically induced clogging as compared to bubble or micro sprinkler. Most point source emitters might be on-line or in-line and it can also be classified as long path, orifice and pressure compensating emitters. The line source emitters are porous pipe, which discharge water along its entire length. Mono-walled and bi-walled perforated polyethylene pipe are commonly used line source emitters

- **VALVE:** It turns on and off water flow at any point within the system. It could be automatic or manual depending on the systems design. The use of an anti-siphon valve (a valve with built in backflow preventer) saves money because it eliminates the use of a backflow preventer valve.
- **PRESSURE REGULATOR**: This component is needed if the pressure is too high either in the mainline or submain, so as to regulate the pressure as desired. It can be installed before or after the valve but traditionally it is installed after the valve.
- **FILTER:** Its function is to purify water for irrigation from suspended impurities to prevent blockage of the pipes and hole of the drip nozzles (emitter). Settling basin, sand, or media filter screen, cartridge filter and centrifugal separator are all used as filters. It may be installed before the valve, pressure regulator or at the water source to protect the valve or pressure regulator.
- **PRESSURE GUAGE** It is a metering device, attached within the system to determine pressure at a certain point. They are very important so as to monitor the system closely.
- **FERTILIZER APPLICATOR:** This component helps to apply fertilizer to the systems water line and it is optional. The fertilizers used are the water-soluble fertilizer.
- **BACKFLOW PREVENTER:** It prevents water from flowing back to the water source. It is needed when water is sourced from the local water authority.
- **END CAP:** It helps to prevent water from running out at the end of the drip tubes.

The drip irrigation system explained above obscures the concept of essential simplicity due to its highly sophisticated components. It is mostly used in industrialized nation and the main justification of such capital-intensive project is to reduce cost of labour. The same cannot be said of the African (developing countries) in acquisition of such system due to cost. In this situation a simplified irrigation system is desirable to be designed. This should be done to facilitate installation and maintenance while retaining the basic principles of high efficiency and low volume of irrigation water use. An effort in this direction has lead to research in Israel towards designing a gravitational drip irrigation system (Israel Information Center, 2003).

CHAPTER THREE

3.0: MATERIALS AND METHODS

The preliminary process in the design of this gravitational drip irrigation system includes: the collection and the collation of data needed for the design, the calculation of the rate of evapotranspiration and determining the crop water and irrigation requirements.

3.1: COLLECTION AND COLLATION OF DATA

The initial procedure in the design of this system involves the collection and collation of climatological data of the area where the system will be used. This is because the success of the project depends on the location data. The data used to design this system includes;

3.1.1: CLIMATIC DATA: The consumptive use rate of crops differ from one location to the other due to the effects of climate, which depends on the interaction of it components in conjunction with factors like soil and plant. Climatic data are mainly collected from the appropriate government agency responsible for such. The climatic data used for the purpose of this project was extrapolated from old climatic data files of Ibadan over a period of 20 years. The files consist of climatological data of Ibadan over series of years, which was inputted into a program (CropWat for Windows Version 4.3) developed by Martin Smith of Land and Water Development, a division of F.A.O, Derek Clarke of the Institute of Irrigation and Development studies, University of Southampton; and Khalied El-ackan of the National Water Research center Egypt to calculate the Peak Evapotranspiration rate of Ibadan. The climatic factors include;

- RAINFALL: It is a measure of depth of water falling on a horizontal surface over a period of days, week, month or year. It is very important in that it dictates the agricultural use of land. In arid region like Israel, irrigation is total while in tropical region like Southern Nigeria (Ibadan) it is supplemental. In terms of irrigation, rainfall is the most useful for irrigation planning (scheduling). A reliable rainfall data spanning 5-20 years is desirable. Rain gauge is used to measure rainfall and the unit is in mm or cm. Not all rainfall is effective except the part that contributes to evapotranspiration i.e. runoff during heavy rainfall reduces it effectiveness. The formula below is used for estimating the effective rainfall.

$P_e = f(D)\,(1.25\,P^{0.824} - 2.93)\,(10^{0.000955ET})$

$f(D) = 0.53 + 0.0116D - 8.94 \times 10^{-5}D^2 + 2.32 \times 10^{-7} D^3$. Source: Schwab et al (1993)

where; P_e = estimated effective rainfall (mm); P = mean monthly rainfall (mm);

ET = average monthly evapotranspiration (mm); f(D) = adjustment factor;

D = soil water deficit (mm).

The effective monthly rainfall of Ibadan over a period of 20 years extracted from the old climatic data of Ibadan is given in Table3.1. It can be deduced from Table 3.1 that low rainfall occurs from November to February (dry season) while heavy rainfall occur between the periods of March to October in Ibadan. Hence drip irrigation would be of tremendous benefit to a farmer in Ibadan during the dry season.

- **TEMPARATURE AND HUMIDITY:** These are the most important atmospheric factor affecting the transpiration of water from the stomata of plants. Temperature is a measure of how cold or hot a body is while humidity is the amount of water present in a volume of air. Temperature is measured using thermometer calibrated in degree centigrade while humidity is measured using the wet and dry bulb thermometers. Increasing the humidity of air would decrease the rate of transpiration of plants, but the higher the temperature of a region the higher the rate of transpiration. From Table 3.3 it could be deduced that humidity of Ibadan increases steadily from March to September and this is where the higher quantity of rainfall occurs.
- **WIND:** It can be defined as air in motion. It either increases or decreases transpiration rate and it sweeps away any layer of vapour accumulated around plants leaf. The rate of transpiration increases if the air around plant leaf is replaced with warmer and/or more humid air. The anemometer is used to measure wind velocity (Km/d) and wind vane indicates it direction. The wind value used to calculate evapotranspiration rate for this purpose was measured at a height of 2 meters above ground level. From Table 3.3 it is shown that wind speed is highest during the period of low rainfall in Ibadan i.e. dry season.
- **SOLAR RADIATION:** It has a pronounced effect on transpiration by raising the temperature of the plant leaf above that of the surrounding air and hence transpiration

increases. It also triggers the opening and closing of the stomata due to the presence of light (short-wave radiation) i.e. the stomata of most plants open during the day and closes during the night. It is measured in mm water/day or $MJ/m^2/d$. The value of the mean solar radiation of Ibadan is shown in Table 3.3.

- **SUNSHINE HOURS:** Sunshine duration is relatively very important as other climatic factor.as regards evapotranspiration rate. It determines the rate of photosynthesis and this process in turn has an effect on the amount of water used by the plant during the day. It is measured in hours. The value of the mean sunshine hours of Ibadan is shown in Table 3.3.

3.1.2: SOIL DATA

The soil is the medium in which plants grow and it also store the water needed by plant. A sound knowledge of soil and water relationship is a prerequisite to improvement in irrigation practice. The entry rate of water into the soil, its retention, movement and availability to plant root are all physical phenomenon of water in soil. The soil physical properties that affect the quantity and efficiency of a drip irrigation system include;

- **SOIL STRUCTURE AND TEXTURE:** For the purpose of this project, a medium textured soil was the type of soil that the farmland of Ibadan is assumed to have because most of the soil in Ibadan is medium textured. Table 3.2 shows the property of a medium textured soil and these values were adapted from the old soil data of Ibadan.
- **SOIL INFILTRATION CHARACTERISTICS:** Infiltration is water movement down the surface of the soil under the force of gravity. The rate of infiltration is affected by the soil porosity, permeability and rainfall intensity. The structure and texture of the soil also affects the infiltration capacity of the soil i.e. water infiltrates rapidly in a coarse sandy soil but reverse is the case in a fine textured clay soil (because it restrict water movement through it). For good planning of a drip irrigation system it is expedient to make sure that the rate of water application by the system does not exceed the infiltration rate. This is to prevent ponding of water and as a result, to guard against the wastage of water during irrigation.
- **SOIL MOISTURE:** Infiltration is water movement down the surface of the soil under the force of gravity. The rate of infiltration is affected by the soil porosity, permeability and

rainfall intensity. The structure and texture of the soil also affects the infiltration capacity of the soil i.e. water infiltrates rapidly in a coarse sandy soil but reverse is the case in a fine textured clay soil (because it restrict water movement through it). For good planning of a drip irrigation system it is necessary to ensure that the rate of water application by the system does not exceed the infiltration rate. This is to prevent ponding of water and as a result, to guard against the wastage of water during irrigation. The field capacity (f.c) and the permanent wilting point (p.w.p), is defined as the upper and the lower limit respectively of soil moisture available to plant. The available water zone represents the moisture, which can be stored in the soil for subsequent use by plant. The readily available water is that portion of the available moisture that is most easily extracted by plants i.e. about 75% of the available moisture, while the unavailable moisture cannot be used by plants.

3.2: CALCULATION OF EVAPOTRANSPIRATION RATE

The evaporation of water from the soil surface, coupled with the transpiration of water from plant to the atmosphere is inseparable. These two processes are singly referred to as evapotranspiration, which is often known as consumptive use. To design any irrigation scheme, it is pertinent that evapotranspiration rate of crop be evaluated. This is because in the absence of rainfall, crop evapotranspiration have to be provided for by irrigation. The various methods used in determining crop evapotranspiration can be divided into two categories, which include;

- **DIRECT METHOD:** This involves the use of laboratory equipment. This method includes; the use of lysimeter, field water balance method, soil-moisture depletion studies and field experimental plots.
- **EMPERICAL FORMULAE:** This involves the use of formulae. It is very difficult to obtain or estimate the rate of evaporation directly from experimental field, so it is often determined through calculations by using climatological data. The data discussed above are used in the process of estimating the rate of evapotranspiration by calculation. The empirical formula used in this project is the Penman-Monteih method and the estimated values are as shown in Table 3.3.

Table: 3.1 Average Rainfall Data for Ibadan.

Month	Total rainfall (mm/month)	Effective rainfall (mm/month)
January	10.0	9.8
February	22.0	21.2
March	89.0	76.3
April	139.0	108.1
May	149.0	113.5
June	189.0	131.8
July	160.0	119.0
August	86.0	74.2
September	178.0	127.3
October	155.0	116.6
November	42.0	39.2
December	10.0	9.8

Source: CropWat for Windows Version 4.3

Table 3.2 The Properties of Soil Used

SOIL DATA	
Soil description	Medium
Total available soil moisture (mm/m day)	140.0
Maximum rain infiltration rate (mm/day)	40.0
Maximum rooting depth (m)	900.0
Initial moisture depletion (%)	0,0

Source: CropWat for Windows Version 4.3

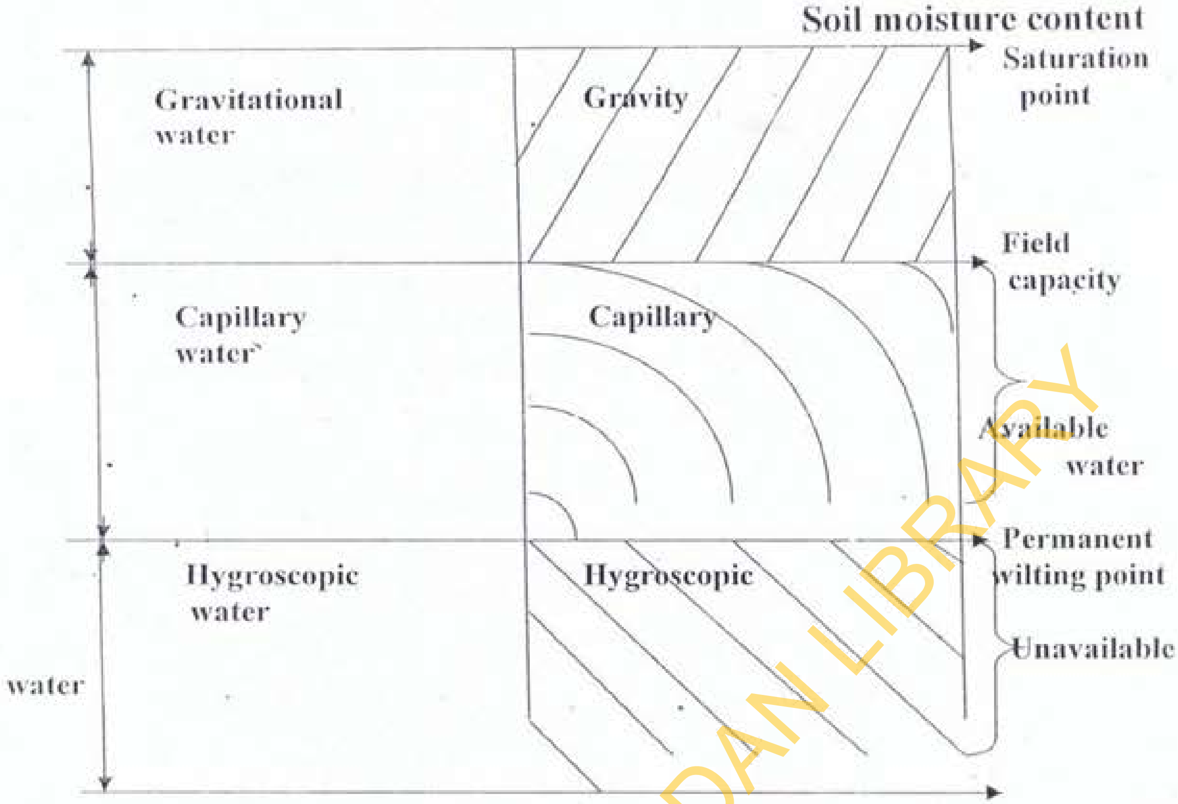

Figure 3.1: Soil Moisture Quantities and Drainage Characteristics

Source: Ogedengbe (2003b)

Table 3.3: Climate and Evapotranspiration data

17/12/2003 CropWat 4 Windows Ver 4.3

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Climate and ETo (grass) Data

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Data Source: D:\CROP\CLIMATE\IBADAN.PEN

Country : Nigeria Station : Ibadan

Altitude: 228 meter(s) above M.S.L.

Latitude: 7.26 Deg. (North) Longitude: 3.54 Deg. (East)

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	32.8	20.6	70.0	104.0	6.5	17.6	4.09
February	34.1	21.3	68.0	104.0	6.9	19.2	4.56
March	34.3	22.5	72.0	86.0	6.3	19.1	4.48
April	33.5	22.5	72.0	69.0	6.0	18.7	4.26
May	31.5	22.1	76.0	69.0	6.1	18.3	3.98
June	29.7	21.6	79.0	69.0	5.1	16.4	3.50
July	27.8	21.0	81.0	43.0	3.0	13.5	2.82
August	27.7	21.0	81.0	69.0	2.3	12.8	2.82
September	29.2	21.0	79.0	69.0	3.0	13.9	3.11
October	30.3	20.8	77.0	69.0	5.3	17.0	3.61
November	31.8	21.0	74.0	86.0	6.8	18.2	3.94
December	32.3	20.6	72.0	86.0	6.8	17.6	3.86
Average	31.3	21.3	75.1	76.9	5.3	16.9	3.75

Pen-Mon equation was used in ETo calculations with the following values for Angstrom's Coefficients:

a = 0.25 b = 0.5

Source: CropWat for Windows Version 4.3

CHAPTER FOUR

4.0: DESIGN

Designing a gravitational drip irrigation system differ to some extent from the processes used to design other irrigation systems. The design starts with the systems layout and determining the type of emitter that would be used. Then the number and diameter of laterals and mainline, coupled with other ancillary components, would be specified.

4.1: PEAK EVAPOTRANSPIRATION RATE FOR CROPS UNDER DRIP IRRIGATION

The rate of evapotranspiration under drip irrigation system is not well defined since the area is not entirely shaded compared to the conventional drip system that irrigates the whole land. Schwab et al (1993) suggested the following water use rate for drip irrigation design.

$$ET_t = ET \times P / 85 \qquad 4.1$$

Where; ET_t = Peak evapotranspiration rate for crops under drip irrigation (mm/day)

P = Percentage of the total area shaded by the crop (%)

ET =Peak conventional evapotranspiration rate for the crop (mm/day)

The peak conventional evapotranspiration rate (Table 3.3) was 4.56 mm/day (this value was selected because it is the maximum rate of evapotranspiration for the location). Assuming a matured vegetable plant shaded 80% of the area, and then the peak evapotranspiration rate for this design is;

$ET_t = 4.56 \times 80 / 85 = 4.29$ mm/day

4.2: VOLUME OF WATER REQUIRED PER PLANT

The volume of water that is required by plant is a function of the peak evapotranspiration rate and the emission uniformity (Schwab et al, 1993). Hence;

$$\text{Volume of water / plant} = \frac{ET_t \times \text{area / crop}}{Eu} \qquad (4.2)$$

Where; Emission Uniformity (Eu) = 87.5% (See appendix 1)

Area / crop = 0.5m × 0.5m

ET_t = 4.29 mm/day = 0.00429 m/day. Therefore the volume of water required per plant per day is

$$\frac{0.00429 \times 0.5 \times 0.5}{0.875} = 0.00123\ m^3/day = 1.23\ l/day$$

4.3: EMITTER DISCHARGE

The emitter discharge will depend on the hours of operation per day to supply the required volume of water to the plant. The volume of water required per plant per day is 1.23 l/day (0.05125 l/hr). If 2 liters is delivered per hour by the emitter (Available drip emitters from Dizengoff Agric. A division of Dizengoff West Africa Nig. Ltd, Iwo road, Iyana Church, Ibadan).

Then 1.23 liters will be delivered in 1.23/2 =0.615 hours. Hence, the irrigation schedule will be 0.615 hours per day (approximately 37 min per day)

This implies that each lateral would deliver 50 x 0.05125l/hr x 0.615hr = 1.5759 liters (since there are 50 emitters on a lateral) and the mainline would deliver 100 × 1.5759 l = 157.59 liters (since three are 100 laterals on the mainline).

The head (pressure in m) of reservoir above the emitters fixed on the laterals (the datum) is given thus:

Required Discharge per Emitter = 0.05125 l/hr

Length of Lateral = 50 m

Spacing between Emitters on a Lateral = 0.6 m

No of Emitters per lateral = 50 / 0.6 = 83.33

Discharge per lateral = 0.05125 l/hr x 83 = 4.27 l/hr

The pressure at which the lateral would operate so that the emitter could deliver the specified amount of water (2 l/hr) was obtained from the manufacturer's chart and the value was approximately 2.5 meters respectively. Therefore, pressure in the lateral is 25.65 kPa, given that 1 m of water-head is equivalent to 10.26 kPa.

4.4: EMITTER SELECTION

This depends on the crop to be irrigated, filtration requirement and also on grower's preference. The various emitters include; line source, point source, bubbler and micro sprinkler emitters. The point source emitter was chosen for this design due to its availability. Pressure compensating, drippers (NETAFIM) obtained from Dizengoff are equipped with an independent pressure compensating mechanism to ensure even distribution, regardless of the lands topography, or water pressure level. It has a coefficient of variation of 0.03.

4.5: DESIGN OF THE LATERAL AND MAINLINE

The pressure variation in the lateral is normally kept within the range of the value chosen for the emission uniformity. (ASAE, 1985)

$$Eu = 100\left(1.0 - \frac{1.27}{n} C_v\right)\frac{q_m}{q_a} \qquad (4.3)$$

Where; Eu = the uniformity of emitter discharge rates throughout the system (0.875)

n = the number of emitters per plant (1)

C_v =manufacturers coefficient of variation (0.03)

q_m = minimum emitter discharge rate for the minimum pressure in the system (l/hr)

q_a =average or design emitter discharge rate (l/hr)

q_m / q_a = ratio of minimum to average emitter discharge

Thus $q_m / q_a = 87.5 / 100 \{1 - (1.27 x 0.03/1)\} = 0.91$

The above statement implies that the pressure variation in the system should be such that the ratio between the minimum emitter discharge and the average emitter discharge must not exceed 0.91.

4.6: FRICTIONAL LOSS CALCULATION IN THE LATERAL

The frictional loss in the lateral was calculated by using the Darcy-Weisbach equation, which is written in the form

$$H_L = \frac{(K)(C)(L)(Q^m)}{D^{2m+n}} \tag{4.4}$$

Where; K = frictional factor that depends on pipe material

L = length of pipe (m); Q = flow rate (l/min); D = diameter of pipe (mm)

C, m, n = constants (See in appendix 2 respectively)

The value of K can be determined from the formula

$$K = 0.811\ (f/g) \tag{4.5}$$

Where; f = the frictional factor and g = acceleration due to gravity

$$f = 64 / Re; \tag{4.6}$$

For Re < 2000 (the flow is laminar)

$$f = 0.32\ Re^{-0.25} \tag{4.7}$$

For Re between 2,000 and 10,000 (the flow is turbulent)

$$f = 0.80 + 2.0\log[Re/\sqrt{f}] \tag{4.8}$$

For Re greater than 100,000 (fully turbulent flow)

$$Re = \frac{(\rho)(D)(v)}{(K_0)(\mu)} \tag{4.9}$$

Where; Re = Reynolds number (dimensionless); ρ = density of water (g/cm^3);

v = average velocity (cm/s); μ = Viscosity of fluid (N-s/m^2)

K_0 = constant i.e. 10 for ρ in g/cm^3

Barb losses from on line emitters, which protrude through the pipe wall to obstruct flow, must also be included in the losses due to head. These losses are read from a graph given in as equivalent pipe length in feet for various sizes of barbs and inside diameter of lateral (James, 1993).

To choose a lateral pipe diameter 16, 18 and 20mm diameter pipe would be considered for selection. Taking the 16mm diameter pipe first, the head loss can be calculated thus

Let ρ = 1 g/cm^3, D = 1.6cm, Q = 1.5759/3600 (l/s), μ = 1.002 × 10^{-3} at 20°c, K_0 = 10

Velocity (v) = Q/A

Where; A = area of pipe ($\pi D^2/4$)

$$v = \frac{1.5759/3600 \text{ l/s} \times 1000 \text{ cm}^3}{(1.6\text{cm})^2 \times 3.142/4} = 0.2177 \text{ cm/s}$$

$$Re = \frac{1 \times 1.6 \times 0.2177}{10 \times 1.002 \times 10^{-3}} = 34.76$$

Since Re is < 2,000, then the flow is laminar hence

f = 64/34.76 = 1.8412

K = 0.811 × 1.8412 / 9.81 = 0.1522

Correcting for barb losses, equivalent length L = 50 + (number of emission device) × C_L

Where; C_L =0.36 ft = 0.11m; and no of emission device is 83

L =50+ 83 × 0.1522 =62.63m

$$H_L = \frac{0.03 \times 277778 \times 62.63 \times (0.0263)^2}{(16)^5} = 3.44\text{x}10^{-4} \text{ m}$$

The results of head loss for other pipe diameter and cost per meter length of lateral is shown in Table 4.3. The 16 mm pipe was chosen due to the low cost per meter length when compared with the other two pipe diameters that can equally fit into the design. When tested for pressure variation i.e. whether it is within the acceptable range before usage compared to the other pipes as a result of its lower cost. The pressure variation within the lateral can be calculated thus; Pressure variation in pipe = $P_u - P_d$ (4.8)

$P_d = P_u - k\,(h_l \pm \nabla z)$ (4.10)

Source: James (1993).

Where; P_u, P_d = pressure at upstream and downstream positions, respectively (kPa)

h_l = energy loss in pipe between upstream and downstream (m)

∇z = elevation difference between upstream and downstream (m)

k = unit constant (k = 9.81 for P_u, and P_d in kPa)

But $h_l = f \times H_L + M_l$ (4.11)

Where f is a constant depending on the method of estimating H_L. It is 0.338, for 100 number of outlets which is the nearest to the designed value of 83; and m=2 in Darcy-Weisbach equation (see appendix 2).

h_f = minor losses through fittings (it is assumed negligible since there are no losses along the pipe line)

Therefore $h_l = (1.8412 \times 3.44 \times 10^{-4}) + 0 = 6.34 \times 10^{-4}$

Substituting into equation 4.10 gives $P_d = 25.65 - 9.81 \times 6.34 \times 10^{-4} = 25.64$ kPa

Pressure variation = (25.65 – 25.64) =0. 01 kPa

A pressure variation of ±5 % is given as the design criteria for choosing a lateral pipe diameter in drip system (Larry, 1988). The above pressure variation value is within design range. Also, the 16 mm pipe cost less. Thus the design is acceptable and hence the lateral design is o.k.

Table 4.2 Equation 4.4 Parameters.

Method of computing H_f	*C*	*m*	*n*
Darcy-Weisbach	277778	2.0	1.0
Hazen-Williams	591722	1.85	1.17
Scobey	610042	1.90	1.10

Source: Larry, (1998).

Table 4.3: Calculated Head Loss and Cost of the lateral pipes

Pipe diameter (mm)	16	18	20
Frictional loss (m)	3.44×10^{-4}	1.96×10^{-4}	1.19×10^{-4}
Cost / m length of lateral	N 80	N 140	N140

4.7: FRICTIONAL LOSS CALCULATION IN THE MAIN LINE

The main line pipe diameter that is available is the 25mm and 30mm. Choosing the 30mm pipe, the length of main that will be used to distribute water to the laterals is 100 meters. The rate of flow of water in the main line would be the rate of flow in each of the lateral multiplied by the number of laterals (Q in the main = 1.5759 × 100 = 157.59 l/hr)

$$v = \frac{157.59 / 3600\ (l/s) \times 1000\ (cm^3)}{(3\ cm)^2 \times 3.142 / 4} = 6.1921\ cm/s$$

$$Re = \frac{1 \times 10 \times 6.1921}{10 \times 1.002 \times 10^{-3}} = 6179.73$$

Since Re is between 2,000 and 10,000, the flow is turbulent, hence;

$f = 0.32\ Re^{-0.25} = 0.0361$

$K = 0.811 \times 0.0361 / 9.81 = 0.0030$

$$H_L = \frac{0.0030 \times 277778 \times 100 \times (2.6265)^2}{(30)^5} = 2.35 \times 10^{-2}\ m$$

The result of head loss in the 25mm diameter pipe is also computed and tabulated below,

Table 4.4: Calculated Head Loss and cost of the Main pipe

Diameter of pipe (mm)	25	30
Frictional loss	6.46×10^{-1}	2.35×10^{-2}
Cost / meter length	N150	N 200

The 30mm pipe diameter was chosen due to its lower head loss so that it is tested for pressure variation. The pressure variation in the main line pipe is found thus;

$h_l = 0.0361 \times 2.35 \times 10^{-2} + M_l$ (from 4.11)

M_l = minor losses = $k V^2 / 2g$

Where, V = 6.192 cm/s = 0.06192 m/s

k= loss coefficient (it is 1.8 for standard tee entrance)

M_l for 101 standard tee coupler joining the lateral to the main line equals

$$\frac{101 \times 1.8 \times 0.06192^2}{2 \times 9.81} = 3.55 \times 10^{-2} m$$

Then $h_l = 0.0361 \times 2.35 \times 10^{-2} + 3.55 \times 10^{-2} = 3.63 \times 10^{-2} m$

P_d in the main is the P_u at the lateral = 25.65 kPa

$P_u = 25.65 + 9.81\ (3.63 \times 10^{-2} + 0) = 26.00$ kPa

Pressure variation = 26.00 – 25.65 = 0.35 kPa

The pressure deference in this design is very small i.e. not up to 10 % of the pressure in the mainline (James,.1993). Therefore the mainline design is ok.

CHAPTER FIVE

5.0 DESIGN DISCUSSION

5.1. SYSTEMS PERFORMANCE- EFFICIENCY.

The overall efficiency of a farm irrigation system is the percentage of water supplied to the farm that is beneficially used for irrigation. Net economic efficiency is to be estimated by mathematical expectation of additional net income. The overall performance of this designed irrigation scheme is obtained using the equation suggested by Larry (1998), presented bellow:

$$E_i = (Er/100 \times E_c/100 \times E_a/100) \qquad 5.1$$

Where,

E_i = overall system efficiency

E_r = reservoir storage efficiency

E_c = conveyance efficiency

E_a = application efficiency

5. 1.1. Conveyance Efficiency.

This is the ratio of amount of water delivered to the pipeline from the reservoir, to the amount delivered to the conveyance system. Larry (1998) gives equation 5.2 to be used in computing E_c.

$$E_c = 100(V_{co}/V_{ci}) \qquad 5.2$$

Where

V_{co} = volume of water delivered by the conveyance system (outflow), and

V_{ci} = volume of water delivered to the pipeline system (inflow).

5.1.2 Application Efficiency

This is the ratio of volume of water beneficially used by the crop, V_{bu} to the volume of water delivered to the root zone area V_a. For each *and all* field, E_a can be computed using equation 5.3 (Larry, 1998).

$$E_a = 100(V_{bu}/V_a) \qquad 5.3.$$

Now, V_{bu} = volume of water delivered - ET_o

5.1.3 Reservoir Storage Efficiency

The efficiency with which water is stored in a reservoir is affected by many factors, the most important being evaporation in this case. Since the tank is covered, evaporation loss is assumed negligible. Therefore, in computing this efficiency.

$$E_i = (V_o + \Delta s)/V_i \quad \text{..} 5.4.$$

Where,

V_o=outflow volume from the reservoir during a time interval

V_i = inflow volume into the reservoir during a time interval

Δs = change in storage during a time interval.

5.2 COST ANALYSIS

One major important objective of this irrigation system design is determining the expected annual cost of owing and operating the system. This is in anticipation that banks, government agencies and private individuals for example, could use it to evaluate the economic viability of the project and develop suitable arrangements where and when necessary.

5.2.1 Fixed cost

This is the ownership cost. It is dependent on the level of the system used. Table 5.1 shows equipments used and their corresponding price quotations. This is the initial cost for this project as at February 2004.

5.2.2 Operating cost.

The annual operating cost includes the cost of water, energy, maintenance and repair, and labour. The effect of escalating cost is necessarily ignored due to the fluctuations in the Nigerian exchange rate.

Annual water cost- In many locations, irrigators are charged for the water they used. Charges are normally assessed on volume basis.

Energy cost- The annual energy cost includes all forms of energy used to operate the system. Calculating the quantities of energy used annually to irrigate farm and applying the appropriate price estimate. For this design it is taken as the energy required for lifting water into the overhead tank.

Maintenance and repair cost- this depends on the number of hour that the system operates, the operating environment, and the quality of maintenance. It should be based on the local data whenever possible. Larry (1998) lists the ranges of percent of initial costs that can be used to estimate annual maintenance and repair cost for several irrigation system components. The total annual cost of maintenance and repair is the sum of the components cost. Hence annual maintenance and repair cost is given thus:

Reservoir: (2% of initial cost) = 0.02 x 11600 =	**N** 232
Emitters: (6.5% of initial cost) = 0.065 x 16600 =	**N** 1079
Pipes: (2% of initial cost) = 0.02 x 420000 =	**N** 8400
Total	**N 9711**

Other component parts annual maintenance and repair costs are assumed negligible. Thus, total maintenance and repair costs for the designed system is **N 9711**

The design drawing of the complete layout of the gravitational drip irrigation system was carried out using AutoCAD software package. Part drawings A, B, C, and D of the component parts were also included. All drawings were drawn to scale.

Table 5.1. Bill of Quantity as at February 2004.

Material	*Qty*	*Unit price N*	*Cost price N*
Gate valve	1	300	300
Ball valve	1	550	550
Emitter	83	200	16600
Reservoir Tank	1	8800	8800
Refill Tank	1	2800	2800
Fibrous plumbing rope	25	80	2000
Adhesive	15	100	1500
Standard tee	100	80	8000
Lateral pipe	5000m	80/m	400000
Main pipe	100m	200/m	20000
Clothing filters	2yd.	100	200
Elbow Connector	4	40	1600
Total			*462,350*

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APPENDIX

I Recommended Ranges of Design Emission Uniformity, (E U)

Emitter Type.	Spacing (m)	Topography	Slope (%)	EU Range (%)
Point source	>4	Uniform	<2	90 – 95
		Steep or undulating	>2	85 – 90
Point source	<4	Uniform	<2	85 – 90
		Steep or undulating	>2	80 – 90
Line source	All	Uniform	<2	80 – 90
		Steep or undulating	>2	70 – 85

Source: ASAE (1985)

II Information needed to use equation 4.4

Methods of Computing H_L	(SI Units)	English Units	m	n
Darcy-Weisbach	277778	1.235	2.0	1.0
Hazen-Williams	591722	1.000	1.85	1.17
Scobey	610042	1.000	1.90	1.10

Source: James (1993)

POST GRADUATION EXPERIENCE

PREFACE

My association with the Nigerian Society of Engineers (NSE), Ibadan branch started while I was an undergraduate student in the Department of Agricultural Engineering, Faculty of Technology, University of Ibadan between 1991/92 to 1997/98 academic session. The association was further strengthened when I contested for the NSE graduate of the year in 1999 and 2000 respectively. I was the first runner up in the 1999 contest while I became the winner of the competition in the 2000 contest.

The post-graduation experience discussed in this report span a period of five years after graduation (i.e. from 1998 to date). The report highlighted the description of projects undertaken and also supervised, the abstract or a summary of the main ideas, result findings of the project work and the cost implications if applicable.

NYSC WORK EXPERIENCE (AUGUST 1998 –JULY 1999).

I was posted to Enugu State for the National Youth Service Corps Scheme, after one-month orientation at the camp I was posted to the University of Nigeria, Nsukka. I had the service year with the Department of Agricultural Engineering, Faculty of Engineering, University of Nigeria. In the Department I was directly working as a Corps member with Engr. Dr C.C. Mbajiorgu, a Senior Lecturer in Soil and Water Conservation and Control Engineering Option. The work experience gained during the service year which had really prepared me for my present employment are enumerated below:

(a) Grading and supervision of assignments, course works and examinations of the following courses;

AGE 321: Hydrology for Agricultural Engineers.

AGE 303: Soil Mechanics for Agricultural Engineers.

AGE 511: Agricultural Land Clearing and Development.

AGE 524: Soil and Water Conservation Engineering.

COMP 041: Fortran Programming for Sandwich Students.

COMP D271: Scientific Programming for diploma students.

(b) Coordination of departmental Students' association body known as IRRITRAC. Business Manager during the launching of IRRITRAC magazine titled Agrotech. Compilation of students' lists for the Student Industrial Work Experience Scheme (SIWES) Programme for two semesters. Co-organizers of the departmental week with the Agricultural Engineering Students' Society Executives.

1. PROJECT UNDERTAKEN AND PUBLISHED IN DECEMBER 1998.

Description: The Development and Evaluation of a flat-type wooden incubator.

Abstract: A flat-type, 60-egg capacity incubator was designed, constructed and tested. The incubator differs from existing designs in that the cabinet was made from 3-ply, 4mm thick interior grade plywood to reduce cost and at the same time enhance heat insulation. Also, two kerosene lanterns were provided to supplement heat generation by three 40W electric bulbs during electricity outages as commonly experienced in Nigeria. When tested with 30 fertilized eggs of a commonly sold chicken breed (broiler), incubated at average temperature of 38°C and relative humidity of 58%, the chicks were hatched within 20 days. Relatively high percentages of fertility and hatchability of 86.2% and 76% respectively, as well as a relatively low chick mortality rate of 18.5% were recorded.

Conclusion: The novel approach of using plywood as the construction material and improvising the humidifiers and supplementary heat sources within the incubator paid off with a relatively high percentage hatchability and a corresponding low mortality rate obtained by hatching with the incubator. The total cost of production of the incubator as at 1998 when it was published was ₦3, 090.00. This research report has been shared with other researchers and engineers by publishing the project findings in Journal of Applied Tropical Agriculture, Volume 3; Number 2; December 1998.

2. PROJECT UNDERTAKEN AND PUBLISHED IN NOVEMBER 2001.

Description: Verification of Discharge Coefficient of Rectangular Side Weirs

Abstract: The characteristics of flow over side weirs are taken into consideration to verify the discharge coefficient for sub critical flow conditions under the assumption of constant-specific energy. The main channel discharges, length of weir crest and sill height of the weir are treated as controlled variables. The discharge coefficient **Cd** is found to depend on the Upstream Froude No $\mathbf{F_1}$ and also on the ratio of sill height to upstream flow depth $\mathbf{S/Y_1}$. *Simple linear regression analysis* was conducted to establish the relationship of **Cd** with both $\mathbf{F_1}$ and $\mathbf{S/Y_1}$ taken separately while multiple regression analysis was conducted to establish the relationship of **Cd** with both $\mathbf{F_1}$ and $\mathbf{S/Y_1}$ taken together. **Cd** decreases with increase in $\mathbf{F_1}$ while **Cd** increases with increase in $\mathbf{S/Y_1}$ ratio when taken separately. When taken together, it was clearly evident that variation in **Cd** was largely due to $\mathbf{S/Y_1}$ ratio while the effect of $\mathbf{F_1}$ was relatively negligible.

Conclusions: **(1)** **Cd** was computed on the assumption of estimating the downstream depth on the basis of constant specific-energy. **Cd** evaluated using depth measurements of downstream section without recourse to constant specific-energy assumption gave standard error of 0.9239 (i.e. S_n = 92.39%) from the analysis of the accuracy of the mean of flow depth measurement values of downstream section.

(2) A first-order polynomial from multiple regression analysis describing the relationship of **Cd** with both $\mathbf{F_1}$ and $\mathbf{S/Y_1}$ ratio taken together was developed and the result obtained validate the proposal expression for **Cd** by Singh *et al.* (1994) "Discharge of Rectangular Side Weirs", Journal of Irrigation and Drainage Engineering, ASCE, 120 (4), 814 – 819. **(3)** Student's t-distribution test shows that there is no significant difference between **Cd** values from experimental data and from multiple regression analysis at 0.01 level of significance. **(4)** The itemized cost of construction of the rectangular main and branch channels for the project was estimated at ₦11, 050.00 as at June 2000, when the project was undertaken in the Department of Agricultural Engineering, University of Ibadan. The research findings were published in Journal of Applied Science and Technology, Volume 1, Number 1, November 2001.

3. PROJECT UNDERTAKEN AS EDITOR IN NOVEMBER 2002.

Description: Agricultural Engineering in Nigeria: 30 years of University of Ibadan Experience.

Preface: myself, Engr. Dr. E. A. Ajav and Engr. Dr. A. O. Raji, edited the book. It was published as a contribution of Agricultural Engineering to Nigerian Agriculture as well as other sectors of the economy. The book is designed to give the modest contributions of Agricultural Engineering at the University of Ibadan since 1972. The history of Agricultural Engineering Department at the University of Ibadan is highlighted. The book gives seven invited papers on different aspects of Agricultural Engineering and they are:

(i) Agricultural Engineering and the Society by Engr. Prof. J. C. Igbeka; the present Head of Department, University of Ibadan.

(ii) Level of Agricultural Mechanization in Nigeria by Engr. Prof. E. U. Odigbo; Department of Agricultural Engineering, University of Nigeria, Nsukka.

(iii) Post-Harvest Technology in Nigeria by Engr. Dr. Ajisegiri; Department of Agricultural Engineering, Federal University of Technology, Minna.

(iv) An Overview of Oil palm Processing in Nigeria by Engr. G. A. Badmus; Head, Agricultural Engineering Research Division, Nigerian Institute of Oil palm Research, Benin City.

(v) Environmental Waste Management in Nigeria: A Review by Prof. A. Y. Sangodoyin and Engr. Dr. A. O. Coker; Agricultural and Civil Engineering Departments respectively, University of Ibadan.

(vi) Wood Processing and Utilization in Nigeria: The Present Situation and Future Prospects by Engr. Rtd. Prof. E. B. Lucas and Engr. Dr. A. O. Olorunnisola; Agricultural Engineering Department, University of Ibadan.

(vii) The Role of Agricultural Engineering in Industrial Development in Nigeria by A. Osobu.

The book was published by the Department of Agricultural Engineering, University of Ibadan in November 2002 with the vision "To achieve and sustain self-sufficiency in food and fiber through Engineering".

4. INTERNATIONAL POST GRADUATE TRAINING EXPERIENCE

Preamble: I attended the International Postgraduate Programme in Israel between 10^{th} of March to 6^{th} of April 2003.

Description: The 16^{th} International Postgraduate Course in Crop Weather Modelling.

Abstract: The World Meteorological Organization (WMO), Regional Meteorological Training Center (RMTC) for postgraduated training in applied meteorology, Bet-Dagan, Israel, organized the course. It was funded by Israel's center for International Cooperation, known as MASHAV in its Hebrew acronym. Founded in 1958, as part of the Ministry of Foreign Affairs and it is responsible for initiating and implementing Israel's development cooperation Programme worldwide. A total of twenty participants from eleven countries attended the course. Three came from Nigeria and others are; one from China, two from Ethiopia, five from India, one from Mongolia, one from Myanmar, one from Philippines, three from Sri-Lanka, one from Thailand, one from Uganda and the last participant came from Uzbekistan.
The modules and curriculum of subject taught includes; Use of Computer in Modelling, Climate Requirements of Crops, Simulation of Crop Yields, Study Demonstration Trips and Religious Historical Tours.

Conclusion: The course which was held between March and April 2003 for four weeks, helped in transferring the expertise and technologies which have assisted Israel in its own path to technological development in Agriculture to other nations that participated in the Postgraduate Training Programme. It has also further strengthened International Cooperation between Nigeria and Israel's Ministry of Foreign Affairs.

5. POSTGRADUATE TRAINING FOR UNIVERSITY STAFF IN 2004.

Preamble: Following a widely circulated advertisement in the University's official bulletin for proposals on training from members of staff of the University of Ibadan, a total of two hundred and seventy-eight (278) proposals were submitted by both the academic and non-academic staff for screening and evaluation. A carefully selected University-wide Panel screened and evaluated the proposals under a conference assessment meeting. A total of sixty-three (63) applicants were successful and were therefore awarded the grant for training in identified Reputable Institutions in America, Europe and other parts of the world. I am one of the successful applicants awarded the ***John D and Catherine T. MacArthur Foundation Grant.*** I made use of the award under the three-month short-term category by having some training at the Department of Agricultural Engineering, University of Peradeniya, Sri – Lanka.

Training Benefits / Experience

(1) The training has helped me to have a better understanding and knowledge about my doctoral research work because I was attached to a Professor of Hydrology. He introduced me to many standard Hydrological models that are being used in the developed world and how to adapt such to tropical environments as is common to Sri Lanka and Nigeria.

(2) I was able to establish contacts with researchers, professionals and International Organizations such as International Water Management Institute (IWMI), which had its head quarters at the capital city, Colombo. Also I was given recent published materials at IWMI's publication's unit and I was also included in their mailing list upon request.

(3) The training at the Irrigation Training Institute (ITI) has provided me with exposure to the technical details that helped me in updating my lecture materials and also the design work submitted along with other documents for the Corporate Membership registration.

(4) Being one of the few that was awarded and being able to utilize the MacArthur Foundation Grant has further strengthened the capacity building at the Faculty of Technology and indeed the University of Ibadan.

6. PROJECT SUPERVISED

Description: Design and Construction of a Gravitational Drip Irrigation System.

Abstract: I was involved in the supervision of the design, installation and testing of the gravitational drip irrigation system, carried out in the Department of Agricultural Engineering, Faculty of Technology, University of Ibadan. This irrigation system was designed to suit farmlands not more than one hectare. Preliminary studies were carried out and climatological data collected were used to determine the rate of crop evapotranspiration used for the system's design i.e. 4.56mm/day for Ibadan climatic zone. The system has four laterals and each is 4m long with pressure-compensating emitters to distribute water. Test carried out shows that it can deliver 2.1 litres/hour of water with an operating head of 0.969m and the overall system's efficiency was found to be 94%. The total cost of production of this small scale irrigation project was estimated at ₦10, 350 as at February 2004.

6. **PROJECTS SUPERVISION IN PROGRESS:**

- Prediction of runoff from micro-catchments using rectangular wooden soil tank.
- Solar Distillation of saline water for Small Scale Water Demands.
- Determination of Potential Evapotranspiration (PET) using Priestly-Taylor method.
- Design and Operational testing of an infiltrometer for Determination of Field Soils Infiltration Capacity.
- Effect of Mulching and Drip Irrigation Application Frequency on Growth Performance and Grain Yield of Sweet Corn.