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Design and Construction of an Electrofishing Equipment

I. T. Okoko*‡

*Department of Electrical Electronic Engineering, University of Port Harcourt, Rivers State, Nigeria.

(ilomarata@gmail.com)

Department of Electrical Electronic Engineering, University of Port Harcourt, Rivers State, Nigeria,

ilomarata@gmail.com

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Abstract- Electrofishing plays a vital role in surveying fishes, monitoring and determining the size of fish population and species. This study entails the procedure for the design and construction of an electrofishing equipment. The study highlights the consistent and harmless efficient capture method that electrofishing constitutes. It highlights the growing endorsement of electrofishing as a safe and cost-saving fish sampling gear and method for degrading the incidence of inadequacies, fatalities and economic loss in fisheries management. The study derives its impetus from "local action paradigm" which has its principles hinged on galvanotropisms. In the main, the study explains the results arrived at during implementation stage of the three testing location, the results show the effectiveness of the electrofishing equipment for fish surveying and sampling.

Keywords- Electrofishing, Fishing Technique, Net, Anode, Cathode, Pulse Direct Current, Model.

Özet- Elektro balık avlama, balıkların incelenmesinde, balık popülasyonunun ve türlerinin büyüklüğünün izlenmesi ve belirlenmesinde hayati bir rol oynar. Bu çalışma, bir elektro-balık teçhizatının tasarımı ve yapımı için prosedürü içermektedir. Çalışma, elektro-balıklamanın oluşturduğu tutarlı ve zararsız verimli yakalama yöntemini vurgulamaktadır. Balık avlama yönetiminde yetersizlik, ölüm ve ekonomik kayıp insidansını azaltma yöntemi olarak güvenli ve maliyet tasarruflu bir balık örnekleme ekipmanı ve elektro balık avının artan onayını vurgulamaktadır. Çalışma, itici gücünü, ilkeleri galvanotropizme bağlı olan "yerel eylem paradigmasından" almaktadır. Esas olarak, çalışma üç test yerinin uygulama aşamasında ulaşılan sonuçları açıklar, sonuçlar balık araştırma ve örnekleme için elektro balık avlama ekipmanının etkinliğini gösterir.

Anahtar Kelimeler- Elektrofishing, Balıkçılık Tekniği, Net, Anot, Katot, Darbe Doğru Akım, Model.

1. Introduction

The rapid increase of fish inventory survey gears without a commensurate study to degrade the incidence of inadequacies and fatalities inflicted on those carrying out fish sampling is an invaluable omission that needs to be addressed by Fisheries Management Centres of the global community. This paper is embarked upon with the primary objective of filling this gap through the design, and construction of an electrofishing gear equipment. It seeks to entrench the enforcement of strict adherence to industry based specification vis-à-vis its operation; and as a corollary not only minimise; as some innovators would want to; but totally obliterate the short comings of injuries/fatalities that has over the years characterised its functional perspective as a sampling gear.

Global literature on the efficiency and safety spectrum of contemporary fish sample survey gears is replete with demeaning instances of economic loss and fatalities occasioned by fishing gears. As [1] recounts that certain fishing techniques are used because they are very efficient. However, many of these techniques are also very destructive to ecosystems and the physical environment."[1] went further to state "Unfortunately many modern fishing technique are destructive in one way or another. Some techniques are physically harmful to our environment, while others catch large amounts of fish by catch, which is marine life that is unintentionally caught in the fishing gear."

The study seeks to remind humanity of the consistently made allegations of fatalities/injuries that have continued to smear the renown of "electrofishing", which unfortunately takes its toll on surveyors and their target population due to lack of comprehensive knowledge. This study adds to the array of such ameliorative measures by recognising the potentials of the "electrofishing gear as the fish sampling method that enables all fish to be counted…but requires a high level of training and should only be undertaken by experienced surveyors" [2].

One of the major problems that had consistently burdened the occupational preoccupations of fisheries management organisations worldwide had been the problem of haphazardly negotiated industry-based specification on electrofishing. Especially indicative of this was the fact that; way back in the 1930s, while Europeans were using "direct current" as their approved fish-capture-means; the Americans rather had an affinity for using "alternating current" for the same purpose [3].

It is equally worthy of note that it was not until the 21st century that conscious effort was made; albeit muffled; to arrive at the conclusion that "pulsed direct current" constitute the balance between fish-capture-efficiency and minimising injury rates.[3]

The implication of the aforesaid postulation is that increased rates of fatalities were recorded occasioned by indiscriminate use of different types of current (alternating current (AC), direct current (DC) and pulsed direct current (PDC)) without recourse to laid down specification.

This is dangerous and unprofessional.

The objectives of the study are three-fold in perspective namely:

1.To ensure the design of a circuit diagram for an electrofishing equipment.

2.To construct a functional electrofishing equipment using the circuit diagram as a model. The goal is to have an industry-specification-compliant electrofishing equipment that would not yield to the release of alternating current (AC); but yield to being dually configured for dispensing smooth direct current (SDC) and pulsed direct current (PDC) for effective and efficient electrofishing.

3.To implement the test-running of the electrofishing equipment thus constructed, while being mindful of driving home the imperative of imbibing the culture of being specification compliant.

2. Literature Review of Electrofishing

An attempt is made to review the dynamics of electrofishing in facilitating fish capture for sampling taking into consideration theoretical perspectives and application. It highlights the preferable option open to fisheries scientists in their quest for easier and safer fish-capture-technique for sample survey.

In common parlance, electrofishing can be described as the conscious use of electricity in water for the purpose of incapacitating fish, which renders it easier to catch. [4] defines "Electric fishing (called electrofishing in the USA) as a term given to a number of very different methods all of which have in common the utilisation of the reaction of fish to electrical fields in water for facilitating capture."[5] was more compact and all-encompassing in their exposition of the dynamics and potentials of electric fishing: The principal of electric fishing deals with introducing electric potential gradient in water from one or more cathodes and one anode. Continuous Current (DC), Alternating Current (AC) or Pulsed Direct Current (PDC) are used depending on environmental conditions (conductivity and temperature) and the fish to be sampled (species and size). The various types of current differ in their effects on the fish, i.e. active movement of fish towards the anode [5].

Electrofishing stun fish with the use of electricity before they are caught. It is a scientific known survey method used to sample fish populations; primarily to determine density, abundance and species composition [6].

When executed with precision, it results in no permanent harm to the fish, whereby returning it to their natural state in as little as 2 minutes after being stunned. According [4], electrofishing are of more importance when compared with other survey methods namely snorkelling, netting and bank-side observation; most especially, as it concerns the composition of the species captured. Capture rates as regards electrofishing they say; can be much higher; with almost thirty times greater for electrofishing in comparison with gill netting and twice with other captured species.

The study also found that the method predisposed a consistent and better result than seines, gave a large number of important regression estimates, more fish were caught by total weight, and caught larger fish: the mean catch abilities for numbers of fish caught were 0.69 for the electro shocker and 0.43 for seines. It is also found to be cost effective than hoop nets and where 2 species were caught by hoot net, electric fishing recorded 19 species.

Snorkelling is often suggested as an alternative to electrofishing, however, again sampling efficiency is lower and results more variable than for electric fishing especially for shallow areas with high velocities and coarse substrate. Observing fish from the bank-side has also been assessed as a method of enumerating fish species.

According to information posted on-line and already gone viral [7] "Snorkelling….. is the practice of swimming on or through a body of water while equipped with a diving mask, a shaped tube called a snorkel, and usually swimfins……Use of this equipment allows the Snorkel to observe underwater attractions for extended periods of time with relatively little effort".

It is also worthy of note that electrofishing does not require prior preparation of the site and the requirements in terms of manpower are small when compared with other methods.

3. The Dynamics of Electrofishing

Electrofishing is used in fisheries management as a sampling method. It has proved to be very valuable in situations where other techniques, such as netting, may be ineffective due to the nature of the species the scientist wish to capture, the "target species", or the habitat. And there is no gainsaying the fact that the efficiency of electrofishing in terms of the proportion of a fish population that can be caught varies considerably from site to site, according to a variety of factors. [8] identified nine of these factors, namely:

- Water Conductivity
- Generator Size

- Electrode Configuration
- Current type
- Stream Morphology
- Temperature
- Fish Species and Size
- Operator Efficie ncy and
- Visibility

4. Methodology

The methodology deals with the design and construction implications of the study. Here, the study takes a specific look at the methodological and operational problems of applying the preferred technique (electrofishing) for degrading the incidence of destructive fishing practices; in furtherance of which it deals with the different components that make up the circuit from the block diagram to its design; as well as the method of connection of the equipment. The methodology adopted to achieve this end is Electrofishing. Performed with the right specification, Electrofishing predisposes no permanent harm to fish, which return to their natural state in as little as two minutes after being stunned. Hence, the rationale for keeping abreast with the appropriate requirements and specifications for embarking on the design and construction of Electrofishing equipment.

4.1. Requirements and Specification before Design

The study is concerned with the Backpack model vis-à-vis its requirements and specification before design. The components required in the design and construction of the electrofishing equipment includes:

4.1.1. Battery

The battery is used to store direct current (DC). There are several types of battery which can be used for electrofishing depending on their storage capability and discharge as well as different rating of batteries. The Sealed Lead Rechargeable acid battery was used for the purpose of design and construction of the electrofishing equipment (backpack electrofishing equipment). The sealed lead battery uses a chemical reaction to do work on charge and produces a voltage between its output terminals. It uses a 12Volt, 7.2 Ah and it has to be fully charged before use.

4.1.2. The Transformer

The transformer used in the backpack electrofishing equipment is a push-pull transformer-coupled configuration. It is a type of direct current (DC) to pulsed direct current (PDC) converter; it helps to change the voltage of a power supply unit; and has the potency of stepping it up from 12 volt DC to 220-240 volt PDC. The transformer primary winding is supplied with current from the input line by two pairs of transistors: T1 and T2. The transistors are alternately switched on and off periodically reversing the current in the transformer.

4.1.3. The Power Pack

The power pack comprises of the MOSFET Transistors which are the power transistors, resistors, heat sink, the separators and the connector wires which are connected to the negative and positive terminals of the battery.

In the power pack, the transistors are connected in parallel so that their power would be added to give more wattage. The heat sink connects the two MOSFET transistors together. It is from the body of this metal used as heat sink that the cable is connected to the transformer.

The resistors and the capacitors from SG3524 IC are connected to the gate of the MOSFET where the pulse enters the oscillator. The negative part of the battery is formed by connecting all the terminals of the substrate together. The metallic part of the transistor is the same as the drain; the middle drain is chopped off.

4.1.4. The Oscillator

The oscillator is a device used for generating electric current or voltages by a non-mechanical means. The oscillator is a device that generates its own frequency continually alternating at regular intervals supplied to the primary windings of the transformer. The oscillator circuit consists of resistors, capacitors, electrolytic capacitor and a variable resistor. The oscillator circuit for this project comprises 7 resistors, 2 capacitors, 1 variable resistor and 2 transistors connected together to form a multivibrator at 228Hz or 2.28kHz depending on the input DC voltage 12V DC.

4.1.5. The Wires

Wires are primarily used to connect all electrical components in the form of a bridge between the devices. There is also a switch which is connected to the start port (switch port), the positive cable (anode) and the negative cable (cathode). The switch cable has a single pole double throw switch which is used to control the flow of current from the battery. Pressing the switch button switches the circuit on, enabling it draw power from the battery. Releasing it switches the circuit off.

4.1.6. Electrodes

The anode is connected to the hoop of the landing net which is a conductor while the cathode is left to tag behind in the water. The probe of the net (which is the handle of the landing net) is made of a plastic telescopic tube on which the switch button is located. Backpacks only have a single anode.

4.1.7. Specification of Components for the Design

- Battery: Input voltage: 12V;Capacity: 7.2Ah;Length: 5.95”;Width: 2.56’’;
- Height: 3.71”; Weight: 1.78kg
- Transformer: Input voltage: AC 220V/240V 50Hz; DC 12VX2 1.5AM
- Weight of the components without the battery= 0.51kg.
- Type of Current Used= Pulsed Direct Current (PDC).

4.2. Description of the Design Procedure, Block Diagram, Circuit Diagram, Theory and Design Calculation

Backpack electrofisher generators are either gas or battery powered. The battery powered type was used as the backpack equipment power source derived from a battery fitted to a control box, it triggers the oscillator that generates its own frequency continually and supplies power to the transformer with its pulsed direct current (PDC) on the fish environment causes galvanotaxis in the fish, which results in the fish swimming toward the anode.

The design procedure entails the facilitation of power from battery through the Control Box, which includes the following: power on/off switch. Power in turn flows into the Oscillator and into the transformer, which with a specified voltage that is in tandem and compliant with the fish environment stuns the fish for sampling through two electrodes (cathode and anode) that applies pulsed direct current (PDC) into the water. And as a corollary brings about galvanotaxis in the fish which causes it to swim toward the anode. An effective electrofishing crew of two will be required; one to operate the anode and the other to catch the stunned fish with a dip net. Figure 1 shows a block diagram of the electrofishing process.

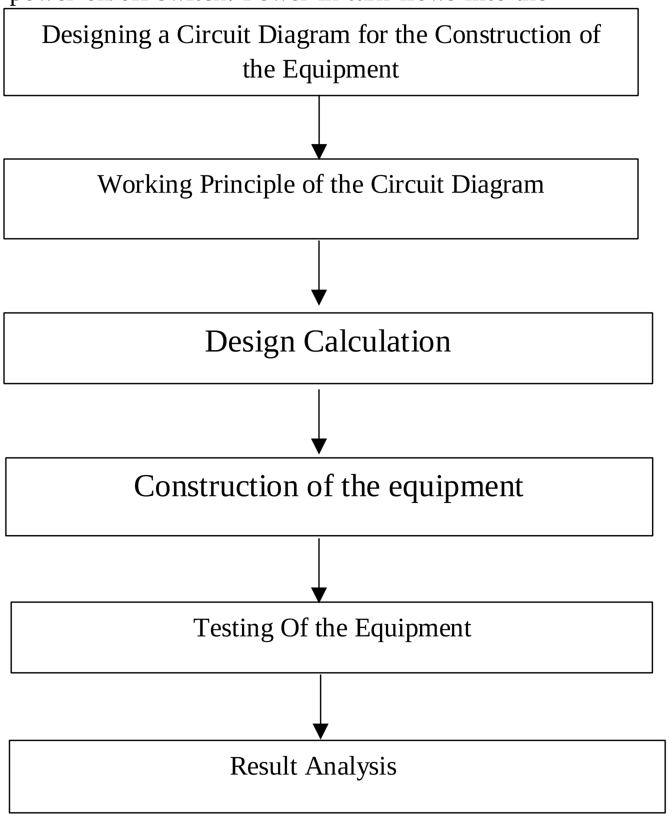

Fig 1. Block Diagram of the Electrofishing Process.

Figure 2 Shows the Developed circuit design during multisim software 2015.

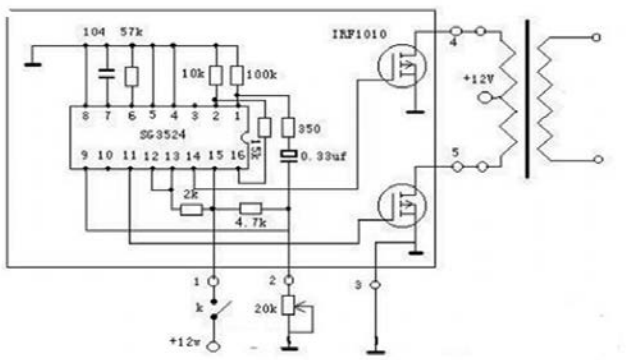

Fig 2. The Circuit Diagram of the Electrofishing Process

The components of the circuit diagram includes:

- Power supply (12v)
- Resistor (100kΩ, 10kΩ, 57kΩ, 2kΩ, 350Ω and 4.7kΩ)
- Variable Resistor: (20kΩ)
- Electrolytic capacitors (104(100nf) and 0.33μf)
- MOSFET transistors: IRF1010 (P channel transistors)
- Transformer (Push-Pull transformer): (12-0-12V primary, 220v secondary) PWM (Pulse Width Modulator) chip SG3524 IC

4.3. Working Principle of the Circuit

The SG3524 (PWM chip) operates at a fixed frequency; the oscillation frequency is determined by one timing resistor (TR) and one timing capacitor (TC).TR set up a constant charging current for TC. So there exists a linear ramp voltage at TC which is connected to comparator. Comparator provides

a linear control of the output pulse width (duration) by the error amplifier.SG3524 contains an inbuilt 5V regulator that supplies as a reference voltage also providing the SG3524 internal regulations control circuitry. A 100k resistor is connected to pin 1, pin 1 which is the negative error amplifier input. A 10k resistor is connected to pin 2, pin 2 which is the positive error amplifier input. Pin 3 is open, neither resistor nor capacitor is connected to it and is known as the oscillator output. Pin 4 and Pin 5 are linked together and it is also a bridged circuit. They are both positive current limiting amplifier input (pin 4) and negative current limiting amplifier circuit (pin 5) respectively. A 57k resistor is connected to pin 6 and its resistor terminal is used to set oscillator frequency. A 104(100nanofarad) capacitor is connected to pin 6 and its capacitor terminal is used to set oscillator frequency. Pin 8 is a linked circuit and it is connected to the ground. Pin 9 is linked to pin 1 by one electrolytic capacitor (0.33µf) and a resistor of 350Ω. It is also an error amplifier compensator pin. Pin 10 is open and is the device shutdown. The oscillator output pulse also acts as a pulse to make sure that both the transistors are never turned ON simultaneously. The duration of this pulse is determined by the value of TC. The pin 11 and pin 14 are connected to the IRF1010 transistor for driving the transformer. Pin 12 and pin 13 are linked together to a 2k resistor and is also connected to a 4.7k resistor. The transformer is 12-0-12V primary, 220V secondary. When signal at pin 14 is high, upper transistor is switched ON and current flows from the +12V source via the upper half of the transformer to the ground. When pin 11 goes high, lower transistor get switched ON and current flow from the +12V source via the lower half of the transformer primary and sinks to the ground. Pin 15 is the positive supply and it is connected to a switch and then to +12V battery. Thus we get positive and negative half cycles of 220V supply. Pin 16 is the reference regulator output. A 15k resistor is connected to pin 16 which is taking pin 16 to pin 2. Pin 1 also links the electrolytic capacitor (0.33µf) and the resistor of 350Ω to 20k variable resistor which is connected to the ground. The electrolytic capacitor is a tank circuit which helps to determine the duty cycle/time pulse.
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4.4. Theory and Design Calculation

The study ascribes explanatory potency in the “local action paradigm” in resolving the causative issue of electrofishing. In doing so, it sees galvanotropisms as its unifying principle. The local action paradigm had evolved soon after 1900 and had been in vogue side by side with the Stimulus-Response Theory. It is sometimes referred to as the alternative theory of the Stimulus-Response Theory [9].

Oscillator circuit: The oscillator controls the frequency of the IC and is programmed TR and TC:
TR(Timing Resistor) is in kΩ(kiloohms)
TC(Timing Capacitor) is in µF(microfarad)
F(frequency) is in kHz(kilohertz)

$$f \approx \frac{1.30}{TR.TC}$$

$$f \approx \frac{1.30}{100\times100^{-9}\times57\times10^{3}}$$

$$=228\text{Hz}$$

$$\approx 2.28\text{ kHz}$$

Fig 3. Photo of Completed System

5. Results and Discussion

This section basically outlines the results and discussions occasioned by the study. With a test plan geared toward constructing an electrofishing equipment for sampling fish through stunning; the following observable results were arrived at in the course of the study elicited discussion sessions at the design; construction and implementation stages.

5.1. Results at the Design Stage

The following results were arrived during the design stage namely:

- The results identified at the design stage was the possibility of replacing the inverter with a power supply unit.
- The study saw the use of a coupled push-pull transformer as the ideal configuration for stepping up the Direct Current (DC) from 12 volt DC to 220-240 volt PDC.
- The study also explored the option of using an N-channel MOSFET transistor.
- It also explored the imperative of soldering the transistors to the Veroboard so as to avoid the impact of heat, which could incapacitate it on account of poor soldering.
- The study see the SG3524 Integrated Circuit as the heart of the construction; care was taken at the design stage to ensure that none of the sixteen(16) pins(in the SG3524) got bent or broken, which would automatically incapacitate and make a nonsense of the entire construction.
- The study also explored the imperative of having the entire circuit connected with connector wires.
- The imperative of using a single pole double throw switch was also explored. The single pole double throw switch serves as the power controller of the whole process.

5.2. Results at the Construction Stage

At the construction stage, the following results were arrived at namely:

- The study created a power supply unit at the construction stage in place of the inverter and it was seen to be effective and compatible with the operations of the construction.
- In furtherance of our objective of stepping up the direct current (DC) from 12 volt DC to 220-240 volt PDC, the stepped up the output of the coupled push-pull transformer by swapping the windings; and as a corollary, the primary winding became the secondary winding, while the secondary became the primary. At the construction stage, we used the primary to act as the output. The imperative of this is to prevent voltage step down, which was no doubt achieved; and effectively too.
- Our design projection of using an N-channel MOSFET transistor suffered a set-back at the construction stage of the electrofishing equipment; as its application resulted in a "feedback" that caused a "flash" on the positive terminal of the battery that further resulted in the burning of the transistors. This predisposed our exploring the option of replacing the N-channel MOSFET transistors with a P-channel MOSFET transistor, which recorded no "feedback" and as such compliant with the construction imperatives of the electrofishing equipment.
- Being conversant with the incapacitating tendency of heat on poorly soldered transistors on the "Veroboard", which results in no output, the study made it a point of duty to effectively solder the transistors to the "Veroboard". Hence, we did not experience any problem of no output.
- Knowing fully well that the SG3524 Integrated Circuit is the heart of the construction, the study took adequate care in ensuring that none of the sixteen (16) pins (in the SG3524) were bent or broken.
- The study had to reconnect the circuit with connector-wires a second time due to their (connector-wires) not being properly aligned with the constituent components of the circuit.
- A single pole double throw switch served as the power controller of the whole process and it was no less effective.

5.3. Results at the Implementation Stage

With the construction work completed with its complement of electrodes (cathode and anode), we embarked on a trial session in a stream at the Choba axis of Obio-Akpor, Local Government Area, Port Harcourt, Rivers State, Nigeria. The following results were recorded, viz:-

- The result was that the study could achieve galvanotaxis and eventual stunning of the fishes in the stream located at the Choba Axis of Obio-Akpor Local Government Area, Port-Harcourt, Rivers State, Nigeria.

Table 1 shows the results gotten during the testing session at stream located at the Choba axis of Obio-Akpor local government area, Port Harcourt, Rivers State, Nigeria.

Table 1. Showing the testing session at the stream located at the Choba axis of Obio-Akpor Local Government Area of Port Harcourt, Rivers State, Nigeria

Testing Session	No. Of Fish Stunned	Type Of Battery Used	Fatalities Recorded	Did Galvanotaxis Occur
1st Testing	22	12v Battery	Nil	Yes
2nd Testing	18	12v Battery	Nil	Yes
3rd Testing	15	12v Battery	Nil	Yes
4th Testing	10	12v Battery	Nil	Yes

- On further trial at the Faculty of Agricultural Technology Fish pond, University of Port Harcourt for a few hours; the study could still achieve galvanotaxis and stunning after throwing fish feed into the pond. The result was that the fishes swam out to eat the fish-feed and promptly stunned as soon as the cathode and anode of the construction were dropped into the pond. There was thus galvanotaxis; and the fish stunned.

Table 2 shows the results gotten during the testing session at Faculty of Agricultural Technology Fish pond, University of Port Harcourt.

Table 2. Showing the testing session at Faculty of Agricultural Technology Fishpond, University of Port Harcourt.

Testing Session	No. Of Fish Stunned	Type Of Battery Used	Fatalities Recorded	Did Galvanotaxis Occur
1st Testing	12	12v Battery	Nil	Yes
2nd Testing	10	12v Battery	Nil	Yes
3rd Testing	7	12v Battery	Nil	Yes
4th Testing	5	12v Battery	Nil	Yes

- The study introduced the use of a big plastic basin to effect our trial session with sizeable volume of water containing two (7) catfish. The result was that galvanotaxis occurred with the fishes moving toward the anode and instantly stunned; and regained consciousness after two minutes of the switch being put off.

Table 3 shows the results gotten during the testing session with a big plastic basin.

Table 3. Showing the testing session with a big plastic basin

Testing Session	No. Of Fish Stunned	Type Of Battery Used	Fatalities Recorded	Did Galvanotaxis Occur
1st Testing	6	12v Battery	Nil	Yes
2nd Testing	5	12v Battery	Nil	Yes
3rd Testing	4	12v Battery	Nil	Yes
4th Testing	3	12v Battery	Nil	Yes

Figure 4 is a bar chart representation of the three testing session

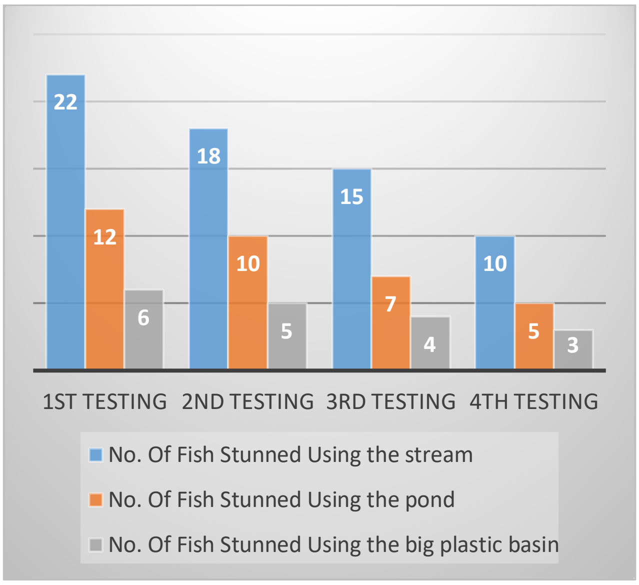

Fig 4. Showing a bar chart representation of the three testing session

6. Discussion

The imperative of adhering strictly to effectively researched design specification cannot be overemphasised. All the three stages are fraught with risks and challenges which cannot be taken for granted if the construction process must effectively translate from the design through the construction to the implementation stage.

7. Concordance with Other Works

The aforesaid deductions and generalisations converges with those of the "power transfer theory for electrofishing which sees the relationship between electrical power in the water and in the fish as a function of the ratio of water conductivity to the effective conductivity of the fish [9].

8. Conclusion

The results of these analysis show that the Electrofishing Technique can be successfully applied with little or no destructive effect to the fish sampling population as well as its habitat. Unlike most harmful techniques such as bottom trawling which rakes up or crushes everything in their way from fish to ancient coral, the Electrofishing option has most often than not been applauded for its generally low mortality rates and habitat friendly operations.

The relative conductivity of the water in the three trial sessions (in the stream at the Choba axis of Obio-Akpor Local Government Area of Rivers State; in the fish pond at the Faculty of Agricultural Technology, University of Port-Harcourt; and in the plastic basin with a sizeable volume of water) of our collectively constructed Electrofishing Equipment does not in any way invalidate the efficiency of the construction; but rather re-enforces the dynamics of "current-types" and water conductivity in the effectiveness of its application; as well as corroborating our findings that "the efficiency of electrofishing decreases with increasing river width and vice-versa".

The relative functionality of the construction at the three trial sessions also constitute a significant commentary on the fact that construction team should strictly adhered to industry-based specification at the design, construction and implementation stage of the project.

9. Recommendations

The analytical framework of the Electrofishing Equipment Technique is consistent with the concept of "power transfer".

The use of the technique for sampling fish populations should not be ignored or put aside without taking into consideration optimal settings that could minimise fatality. In this respect, I concur with the following which is based on the recommendations of [9]. To reduce the possibility of trauma, these measures should be adhered to:

- Use a SDC (Smooth Direct Current) where it is practical.
- When the direct current is not practical, use Pulse Direct Current systems with pulse frequencies or patterns, waveforms and power levels which likely cause the least damage while maintaining adequate capture efficiency.
- Alternating Current is acknowledged by several authorities as the most harmful waveform used in electric fishing. AC should be avoided during most purposes and only be considered when the fishes are to be killed.
- Operate electric fishing systems at the lowest effective power setting that still provides for effective electric fishing. Fish should be observed following capture to ensure that they recover equilibrium within one to two minutes; if not, power should be reduced.
- Use electrodes with the largest effective diameter to eliminate the zone of tetany around the anode.
- Equipment for measuring conductivity and field strength (voltage gradients) in the water should be available on each electric fishing trip to monitor equipment operation and adjust settings and electrodes for the desired size and intensity of the field.
- Minimise exposure to the field and specimen handling-rapidly net fish before they get too close to the anode, and quickly, but gently, place them in oxygenated holding water.
- Change the holding water frequently to ensure adequate dissolved oxygen and avoid fishing in excessive temperatures.

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