Online: 2249-4626
Print: 0975-5896

Global Journal

of Science Frontier Research: H

Environment & Earth Science

Soil Organic Carbon

Ocean Plantation System

Highlights

Qualitative Risk Analysis

Water Consumption Minimizing

Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 1 VERSION 1.0

Global Journal of Science Frontier Research: H
Environment & Earth Science

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Environment & Earth Science
Volume 13 Issue 1 (Ver. 1.0)

Open Association of Research Society

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN):
USA Tax ID: 98-0673427

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Publisher's Headquarters office

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USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

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Contents of the Volume

Global Journal of Science Frontier Research
Environment & Earth Science
Volume 13 Issue 1 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Qualitative Risk Analysis Study of Offshore Aquaculture Ocean Plantation System

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Abstract - Complex system design is increasingly adopting on risk and reliability analysis. Approach population and urban development expand in landscape island countries or countries with long coastlines, city planners and engineers resort to land reclamation to ease the pressure on existing heavily-used land and underground spaces using risk based design. Risk based design has also been used on system that use fill materials from seabed, hills, deep underground excavations, and even construction debris, engineers are able to create relatively vast and valuable land from the sea. An aquaculture industry is the fastest growing food producing sector in the world. Considerable interest exists in developing open ocean aquaculture in response to a shortage of suitable, sheltered inshore locations and possible husbandry advantages of oceanic sites. Adopting the concept of very large floating structure in aquaculture farming in ocean is like to produce more aquaculture product like seaweed. All being property and support for growing aquaculture industry. On risk analysis study of offshore aquaculture ocean plantation system is very important to determine the system functionality and capability that meet sustainable and reliability requirement.

Keywords : *risk, reliability, offshore, aquaculture, algae, oceanic, farming.*

GJSFR-H Classification : *FOR Code: 070401, 260499*

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Strictly as per the compliance and regulations of :

Qualitative Risk Analysis Study of Offshore Aquaculture Ocean Plantation System

Sulaiman O.O. [α], Sakinah N. [σ], Amagee A.[ρ], Bahrain Z.[ω], Kader A.S.A.[¥], Adi M.[§], Othman K. [χ] & Ahmad M.F.[ν]

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Keywords : risk, reliability, offshore, aquaculture, algae, oceanic, farming.

I. Introduction

The technology, for very large floating structures has developed continually, while changing societal needs have resulted in many different applications of the technology for floating structure. Very large floating structure for offshore aquaculture of seaweed could be adapted TO offshore aquaculture ocean plantation system for oceanic farming of fish, prawn, squid and many more. The design of very large floating structure for offshore aquaculture ocean plantation system required a reliable and risk free system with robust mathematical and simulation, risk and reliability of the hydroelastic structure, mooring system, structure, and material. Hence, the study of risk and reliability for the mooring system of offshore aquaculture ocean plantation system is required to make sure the system can function well, be monitored, and accessed safety and efficiency. Typical mooring structure for offshore aquaculture include piers, docks, floats and buoys and their associated pilings, ramps, lifts and railways.

Mooring structure is required to follow local and international requirements for offshore standards, materials, installation timing and surveys. The mooring structures should; be able to withstand in critical saltwater and freshwater habitats when the standards, overwater structures shall be constructed to the minimum size necessary to meet the needs of ocean resources exploration use. Mooring system for VLFS need risk and reliability analysis of the associated criticality. Risk analysis of offshore aquaculture ocean plantation system focus on analyzing mooring structure with hope to help determine safe, reliability and efficiency of the system [3].

Qualitative assessment and quantitative risk assessment analysis methods are explored towards reliable decision support for VLFS. Qualitative assessment analysis employed qualitative tools like checklist, and HAZOP (Hazard and Operability Study) that define the system while quantitative risk analysis, the methods employed include Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA), Risk Control Option based on HAZID (Hazard Identification) process. The risk of disaster cannot be eliminated, but risk can be reduced by employing better safety detection technique and establishing safety criteria prior to an accident occurrence. This paper describe development of simplified but holistic methodology that determine risk based decision support for reliable design and development of VLFS system, the risk analysis focus on mooring structure failure and reliability through employment of risk tools like FMEA, FTA, RCO and HAZID. The significant of this using risk method for VLFS are [1, 4]:

- To avoid system failure according recommendation from quantifying and deduction of improvement measures
- Identify inadequate mooring strength due to poor material quality of fatigue in order to determine required mitigation.
- Identified excessive environmental forces for example under estimated or freak environmental condition and determine solution for system additional uncertainty.

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- Predicted incorrectly mooring tension based on the reviews and analysis of the system.
- Perfumed risk and reliability leads to recommend the best safety level integrity of oceanic aquaculture seaweed plantation for mooring structure to alert the risk and improve reliability of this system.

The study involves conduct and determination the reliability analysis that can reduce the probability of accident risk occurrence and impact in offshore aquaculture system for ocean plantation. Especially mooring structure system integrity and reduction of consequence of failure. The study accesses the risk, system functionality and capability of offshore aquaculture seaweed plantation for mooring structure. The study also estimate the risk in design of mooring structure for deployment of very large floating structure for oceanic aquaculture seaweed plantation and decision recommendation will be offered for level integrity of oceanic aquaculture seaweed plantation for mooring structure.

II. Algae Cultivation

Harvesting seaweed from wild population is an ancient practices dating back to the fourth and sixth centuries in Japan and China, respectively, but it was not until the mid-twentieth century that methods for major seaweed cultivation were developed. Seaweed has traditionally been grown in nearshore coastal waters, with some smaller operations on land. Offshore systems which are the focus of this study are an emerging seaweed culture technology. The seaweed extract, (Carrageenan) is an important hydrocolloids product for food additive ingredient and it is highly demanded in the world market. Seaweed is also used for biomass energy production as well as pharmaceutical and medicinal product The demand for seaweed has created huge market for this raw material, especially, the Cottonii seaweed also known as Kappaphycus (Euchema spp). For exemple, under the Malaysian Government NKEA, there is need to produce 1 million tonnes seaweed every year. Unfortunately, currently there is no proper system or platform to deliver this demand [14].

The mooring system failure analysis is very important part in the development offshore aquaculture ocean plantation system; risk analysis is required to determine the system function duty and performance. Besides that, there will be increasing demand for concept of floating technology worldwide, so the concept of offshore aquaculture ocean plantation system can be applied for the technology platform required. There is currently no systematic and formal proactive methodology for offshore aquaculture floating structure design. Offshore floating structure is required to be reliable in order to to withstand harsh environment. A risk and reliability studies of offshore aquaculture system for mooring structure will contribute to sustainable development of the seaweed farming industry as well as improvement of technology platform for other aquaculture farming in open seas[2, 5].

III. Risk and Reliability Analysis

Risk is defined as an objective, systematic, standardized and defensible method of assessing the likelihood of negative consequences occurring due to a proposed action or activity and the likely magnitude of those consequences, or, simply put; it is "science-based decision-making". "Risk" is the potential for realization of unwanted, adverse consequences to human life, health, property or the environment. Its estimation involves both the likelihood (probability) of a negative event occurring as the result of a proposed action and the consequences that will result if it does happen. For example, in some sector, "Risk – means the likelihood of the occurrence and the likely magnitude of the consequences of an adverse event to public, aquatic animal or terrestrial animal health in the importing country during a specified time period." While some sectors incorporate consideration of potential benefits that may result from a "risk" being realized (e.g. financial risk analysis), others specifically exclude benefits from being taken into account. Risk analysis provides answer to the following questions: What can go wrong?, What are the chances that, it will go wrong? And what is the expected consequence if it does go wrong?

Risk is defined as the potential for loss as a result of a system failure, when assessing and evaluating uncertainties associated with an event, it can be measured as a pair of factors, one being the probability of occurrences of an event, also called a failure scenario, and the other being the potential outcome or consequence associated with the event's occurrence [1]. The definition of "risk" varies somewhat depending on the sector. Most definitions incorporate the concepts of:

i. uncertainty of outcome (of an action or situation),
ii. probability or likelihood (of an unwanted event occurring), and
iii. consequence or impact (if the unwanted event happens).

Risk assessment is the process used to determine the risk based on the likelihood and impact of an event. Failure history through experience (qualitative) and data (quantitative) may be used to perform a risk assessment [2]. Moreover, risk assessment is the determination of quantitative or qualitative value of risk related to a concrete situation and recognized threat.

Risk analysis is concerned with using available data to determine risk posed by safety hazards and

usually consists of steps such as scope definition, hazard identification and risk determination. The phase in which the decision process is inundated with metrics and judgments is called the risk evaluation. The purpose of analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendation, if any, with the aim of preventing similar accidents occurring again. "Risk analysis" is usually defined either by its components and/or its processes. The Society for Risk Analysis www.sera.org offers the following definitions of "risk analysis":

i. a detailed examination including risk assessment, risk evaluation and risk management alternatives, performed to understand the nature of unwanted, negative consequences to human life, health, property or the environment;
ii. an analytical process to provide information regarding undesirable events;
iii. the process of quantification of the probabilities and expected consequences for identified risks.

All risk analysis sectors involve the assessment of risk posed by a threat or "hazard". The definition of "hazard" depends on the sector and the perspective from which risk is viewed (e.g. risks to aquaculture or risks from aquaculture). A hazard thus can be:

i. a physical agent having the potential to cause harm, for example:
   a. a biological pathogen (pathogen risk analysis);
   b. an aquatic organism that is being introduced or transferred (genetic risk analysis, ecological risk analysis, invasive alien species risk analysis);
   c. a chemical, heavy metal or biological contaminant (human health and food safety risk analysis, environmental risk analysis); or
ii. the inherent capacity or property of a physical agent or situation to cause adverse effects, as in
iii. social risk analysis,
iv. financial risk analysis, and
v. environmental risk analysis.

Reliability analysis methods have been proposed in several studies as the primary tool to handle this category of risks [3]. Traditionally, the research and the development of reliability analysis methods have focused on generation and transmission. However, several studies have shown that most of the customer outrages depend on failures at the distribution level [4]. Furthermore, there is an international tendency towards adopt new performance based tariff regulation methods [5]. Hence, reliability of a system can be defined as the system's ability to fulfill its design functions for a specified time. This ability is commonly measured using probabilities. Reliability is, therefore, the probability that the complementary event that will occur will deads to failure. Based on this definition, reliability is one of the components of risk. Safety can be defined as the judgment of a risk's acceptability for the system safety, making to a component of risk management [1].

IV. Modeling Risk for Offshore Aquaculture Seaweed Farming

a) System Functionality and Standard Analysis

The analysis starts with system definition where input and output are highlighted. This followed by risk assessment, a risk assessment is the process used to determine the risk based on the likelihood and impact of an event. Failure history through experience (qualitative) and data (quantitative) may be used to perform a risk assessment (Glickman and Gough, 1993). Risk analysis is concerned with using available data to determine risk posed by safety hazards and usually consists of steps such as scope definition, hazard identification and risk determination. The phase in which the decision process is inundated with metrics and judgments is called the risk evaluation. The purpose of analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendation, if any, with the aim of preventing similar accidents occurring again.

b) Quantitative and Qualitative Risk Analysis

Qualitative analysis relies on statistical methods and databases that identify the probability and consequence. This objective approach examines the system in greater detail for risk [6]. Quantitative risk analysis generally provides a more uniform understanding among different individuals, but requires quality data for accurate results. Quantitative analysis involve introduction of science, holistic and sustainability approach to analyses and quantify risk. It leads necessary weightage to assist decision required for the system in question. There are many methods and technique that have been developed to perform various types of analysis, in areas such as reliability and safety. In order to perform risk assessment and analysis method, this can be determined by quantitative and qualitative risk analysis tools presented in Table 2 below.

Table 1 : Quantitative and qualitative risk analysis

Qualitative Methods
Checklist : Ensures that organizations are complying with standard practice.
Safety/Review Audit: Identify equipment conditions or operating procedures that could lead to a casualty or result in property damage or environment impacts.
What-If: Identify hazards, hazardous situations, or specific accident events that could lead to undesirable consequences.

Hazard and Operability Study (HAZOP): Identify system deviations and their causes that can lead to undesirable consequences and determine recommended actions to reduce the frequency and/or consequences of the deviations.
Preliminary Hazard Analysis (PrHA): Identify and prioritize hazards leading to undesirable consequences early in the life of a system. Determine recommended actions to reduce the frequency and/or consequences of prioritized hazards.
Quantitative Methods
Failure Modes and Effects Analysis (FMEA) Identifies the components (equipment) failure modes and the impact on the surrounding components and the system.
Fault Tree Analysis (FTA) Identify combinations of equipment failure and human errors that can result in an accident.
Event Tree Analysis (ETA) Identify various consequences of events, both failures and successes that can lead to an accident.
Frequency Analysis
Consequence Analysis
ALARP: Possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained.
Cost Effectiveness Analysis

c) Reliability Analysis

Reliability analysis methods have been proposed in several studies as the primary tool to handle various category of risks (Billinton 2004; Janjic and Popovic 2007). Traditionally, the research and the development of reliability analysis methods have focused on generation and transmission (Kwok 1988). However, several studies have shown that most of the customer outrages depend on failures at the distribution level (Billinton and Allan 1996; Billinton and Sankarakrishnan 1994; Bertling, 2002). Furthermore, there is an international tendency towards adopt new performance based tariff regulation methods (Billinton 2004; Mielczarski 2006; Mielczarski 2005).

d) Risk Analysis in Maritime Industry

International Maritime Organization state that, Formal Safety Assessment (FSA) is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and property, by using risk analysis and cost benefit assessment. FSA can be used as a tool to help in the evaluation of new regulations for maritime safety and protection of the marine environment or in making a comparison between existing and possibly improved regulations, with a view to achieving a balance between the various technical and operational issues, including the human element, and benefit between maritime safety or protection of the marine environment and costs. FSA consists of five steps which are, firstly is identification of hazards that means a list of all relevant accident scenarios with potential causes and outcomes, secondly is assessment of risks means that the evaluation of risk factors, thirdly is risk control options that is devising regulatory measures to control and reduce the identified risks, fourthly is cost benefit assessment which determining cost effectiveness of each risk control option and lastly recommendations for decision-making conclusion from the information about the hazards, their associated risks and the cost effectiveness of alternative risk control options.

e) The ALARP Principle

ALARP (As Low As Reasonably Practicable), is a used in the analysis of safety-critical and high-integrity systems. The ALARP principle define residual risk that shall be as low as reasonably practicable, it has been used for decision support for Nuclear Safety Justification, is derived from legal requirements in the UK's Health & Safety at Work Act 1974 and is explicitly defined in the Ionising Radiation Regulations, 1999. The ALARP principle is part of a safety culture philosophy and means that a risk is low enough that attempting to make it lower would actually be more costly than cost lkely to come from the risk itself. This is called a tolerable risk. The meaning and value of the ALARP tolerability risk presented in Figure 1 the triangle represents increasing levels of 'risk' for a particular hazardous activity, as we move from the bottom of the triangle towards the top".

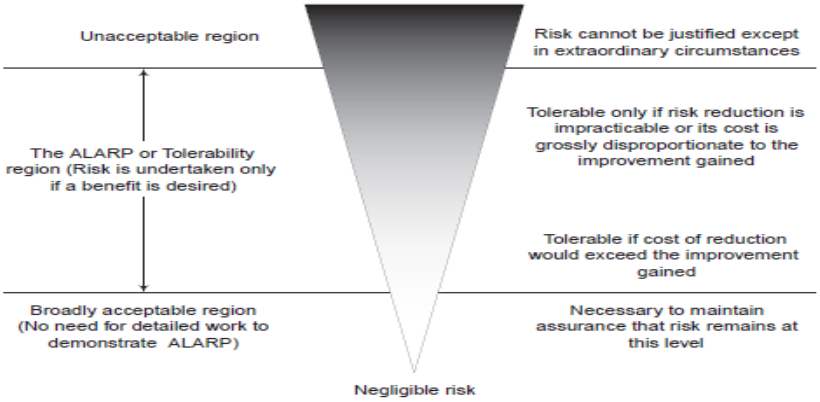

Figure 1 : Levels of Risk and As Low As Is Reasonably Practicable (ALARP)

f) Offshore Industry Risk Analysis

Traditionally, offshore quantitative risk analyses (QRAs) have had a rather crude analysis of barrier performance, emphasizing technical aspects related to consequence reducing systems. However, recently the Petroleum Safety Authority Norway (PSA) has been focusing on safety barriers and their performance, both in regulations concerning health, safety and environment (PSA, 2001) and in their supervisory activities. The development of offshore Quantitative Risk Assessment (QRA) has been lead by the mutual influence and interaction between the regulatory authorities for the UK and Norwegian waters as well as the oil companies operating in the work sea. Also, other countries have participated in this development, but to some extent this has often been based on the British and Norwegian initiatives according to DNV Consulting Support, GI 291, Det Norske Veitas AS, 1322 Hovik, Norway.

In more recent times, efforts to protect citizens and natural resources, has make governments to be more involved, requiring corporations to employ risk-reducing measures, secure certain types of insurance and even, in some cases, demonstrate that they can operate with an acceptable level of risk. During the 1980's and 1990's, more and more governmental agencies have required industry to apply risk assessment techniques. For instance, the U.S. Environmental Protection Agency requires new facilities to describe "worst case" and "expected" environmental release scenarios as part of the permitting process. Also, the United Kingdom requires submittal of "Safety Cases" which are intended to demonstrate the level of risk associated with each offshore oil and gas production facility (ABS Guidance Notes On Risk Assessment, 2000)

g) Offshore Rule for Offshore Structure

The variety of offshore structures concerning the function, size, geometrical configuration and material selection as well as the variability of the environmental factors complicate the development of a unique design procedure (Research Centre Asia Classification Society, 2003). Therefore, the separate investigation of the interaction between the actual structure and the environment is necessary. For mooring system offshore rules (Bureau Veritas, 2010) use reference documents NI 493 "Classfication of Mooring System for Permanent Offshore Units". The design and specification of mooring structure for offshore aquaculture ocean plantation system must be based on all requirements had listed and mention in NI 493 document.

V. Safety and Risk of Offshore Aquaculture

The EC–JRC International Workshop on ''Promotion of Technical Harmonization on Risk-Based Decision Making'' (Stresa/Ispra, May 2000) investigated the use of risk-based decision making across different industries and countries. Under the UK safety case regulations (UK Health and Safety Executive, 1992), each operator in the UK Sector is required to prepare a Safety Case for each of its installations, fixed or mobile, to demonstrate that [14];

i. The management system adequately covers all statutory requirements.
ii. There are proper arrangements for independent audit of the system;
iii. The risks of major accidents have been identified and assessed;
iv. Measures to reduce risks to people to the lowest level reasonably practicable have been taken;
v. Proper systems for emergency arrangements on evacuation, escape and rescue are in place.

Before an installation is allowed to operate, the Safety Case must be formally accepted by the Health and Safety Executive (HSE). Like any aquaculture industry, offshore aquaculture will benefit from thoughtful site selection. Offshore enterprises should be sited in areas that meet optimal biological criteria for

species grow-out and minimize user conflicts with other established groups. Careful site selection may also ensure the development of offshore aquaculture zones or parks to expedite industry development.

a) Failure of Mooring System

It is clearly identified that mooring systems on Floating Production Systems are category 1 safety critical systems (Noble Denton Europe Limited, 2006). Multiple mooring line failure is required to put lives at risk both on the drifting unit and on surrounding installations. There is also a potential pollution risk. Research to date indicates that there is an imbalance between the critical nature of mooring systems and the attention which they receive. The mooring system failure probability is considerably reduced with increases safety factor in particular for system with several parallel loads sharing element. For system with low overall safety factor, the mooring system failure probability is expected to increase with increasing in number of lines, whereas for high safety factors, the system failure probability is expected to reduce with the increasing number of lines. While for the same load distribution and number of lines, a wire system is in general more reliable than a chain system with the same overall safety factor [6].

Risk analysis is a process that provides a flexible framework within which the risks of adverse consequences resulting from a course of action can be evaluated in a systematic, science-based manner. Risk analysis is now widely applied in many fields that touch human daily lives and activities. These include decisions about risks due to chemical and physical stressors (natural disasters, climate change, contaminants in food and water, pollution etc.), biological stressors (human, plant and animal pathogens; plant and animal pests; invasive species, invasive genetic material), social and economic stressors (unemployment, financial losses, public security, including risk of terrorism), construction and engineering (building safety, fire safety, military applications) and business (project operations, insurance, litigation, credit, cost risk maintenance etc.). Risk analysis has wide applicability to aquaculture. So far, it has mainly been applied in assessing risks to society and the environment posed by hazards created by or associated with aquaculture development depending on aquaculture farming in question. The risks include risks of environmental degradation; introduction and spread of pathogens, pests and invasive species; genetic impacts; unsafe foods; and negative social and economic impacts.

b) Risk Framework

The general framework for risk analysis typically consists of four major components:

a. Hazard identification–the process of identifying hazards that could potentially produce consequences;
b. Risk assessment–the process of evaluating the likelihood that a potential hazard will be realized and estimating the biological, social, economic, environmental and failure consequences;
c. Risk management–the seeking of means to reduce either the likelihood or the consequences of it going wrong; and
d. Risk communication–the process by which stakeholders are consulted, information and opinions gathered and risk analysis results and management measures communicated.

c) Risk analysis process

The risk analysis process is a flexible process, Its structure and components vary and depend on the sector (e.g. technical, social or financial), the user (e.g. government, company or individual), the scale (e.g. international, local or entity-level) and the purpose (e.g. to gain understanding of the processes that determine risk or to form the basis for legal measures). It can be qualitative (probabilities of events happening expressed, for example, as high, medium or low) or quantitative (numerical probabilities). General idea of the risk and reliability analysis study of offshore aquaculture ocean plantation system focus on mooring structure of offshore aquaculture systems well as investigation of the problem, goal and objectives, advantage, disadvantage, limitation, design for environment, data reliability. Analysis of historical information from various sources play important role in the outcome of system identification. Flow chart and tables and mathematical governing equation are used to present detail of the process and procedure. The outcome of risk leads to recommendation for system reliability of future work. This study process followed three tier, preliminary system identification, qualitative risk assessment that involve HAZID process and quantitative risk. The process of the approach is more elaborated as followed [7,9].

i. Preliminary system assessment and involve the review of past work data collection and general requirement for mooring structure. Data of analyses of offshore aquaculture ocean plantation mooring system and structure are collected in order to define system, deduce system risk areas and reliability areas.
ii. (HAZID) Hazard Identification qualitative process involves clarification risk. For risk analysis had two processes which are qualitative analysis and quantitative analysis. Qualitative assessment use HAZOP and checklist, Fault Modes and Effect Analysis (FMEA), Fault Tree Analysis (FTA).
iii. Quantitative analysis involves Analytical process that employed hybrid of deterministic, statistical, reliability and probabilistic method to redefine system behavior in the past, present and future.

These use of law physics, help to strength the analysis and support the study of the risk and reliability of this system.

iv. In result of each of the tier can lead to risk matrix, ALARP graph, Risk Control Option (RCO) and cost Effectiveness Analysis.

Since the design of VLFS for seaweed farming is required new methodology based on risk, guideline system for solving a problem with specific components such as phases, tasks, methods, technique and tools that are incoroporated are (Irny, S.I. and Rose, A.A, 2005). It can define as follows:

i. "the analysis of the principles of method, rules, and postulates employed by a discipline",

ii. "the systematic study of methods that are, can be, or have been applied within a discipline",

iii. "the study of description of methods".

VI. Safety and Environmental Risk Model (SERM)

SERM intend to address risk over the entire life of the complex system. SERM address quantitatively accidents frequency and consequences, as shown in Figure 1. SERM methology adapted from [9] intend to address risk over the entire life of the complex system. SERM address qualitative aspect as well quantitatively accidents frequency and consequences VLFS, as shown in Figure 2.

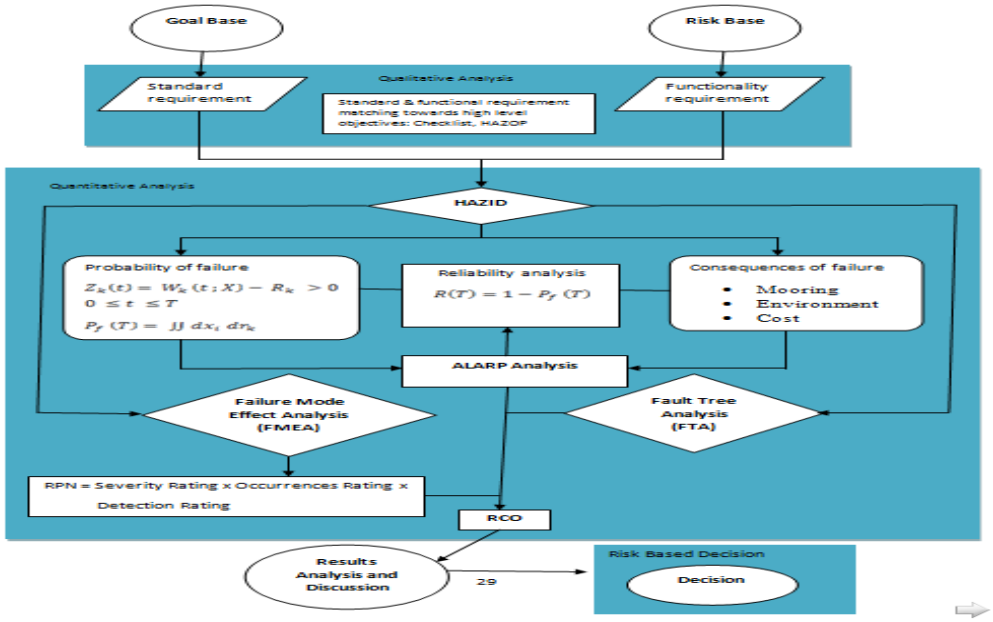

Figure 2 : SERM

a) Data Analysis

The raw collection data is obtained from specific places and method. The right sources should be chosen to make sure the data is reliable and valid for the study analysis. Some of the data will be obtained from model test, Meteorology Department, JPS (Jabatan Pengaliran dan Saliran), Offshore Company, Aquaculture Company and last but not least Seaweed Block System "SBS Project" in Setiu, Terengganu and Sabah.

b) Qualitative risk assessment and analysis method

i. *Checklist*

This is qualitative approach that to insure the organization are complying with standard practice. The checklist can be used as a preparation for system design, deployment, maintenance and monitoring to avoid unnecessary problems and delays. The checklist included in the International Safety Management (ISM) procedures as documentation about checks for maintenance can be adopted for this study. The list can be filled in manually or printout electronically. Checklist analysis is a systematic evaluation against pre-established criteria in the form of one or more checklists. It is applicable for high-level or detailed-level analysis and is used primarily to provide structure for interviews, documentation reviews and field inspections of the system being analyzed. The technique generates qualitative lists of conformance and non-conformance determinations with recommendations for correcting non-conformances. Checklist analysis is frequently used as a supplement to or integral part of another method especially what-if analysis to address specific requirements. The quality of evaluation is determined primarily by the experience of people creating the checklists and the training of the checklist users [8].

ii. *Failure Modes and Effect Analysis (FMEA)*

A failure modes and effects analysis (FMEA) is a procedure in product development and operations management for analysis of potential failure modes within a system for classification by the severity and likelihood of the failures. A successful FMEA activity helps a team to identify potential failure modes based on past experience with similar products or processes, enabling the team to design those failures out of the system with the minimum of effort and resource expenditure, thereby reducing development time and costs. It is widely used in manufacturing industries in various phases of the product life cycle and is now increasingly finding use in the service industry. Failure modes are any errors or defects in a process, design, or item, especially those that affect the intended function of the product and or process, and can be potential or actual. Effects analysis refers to studying the consequences of those failures. The Figure 3 below shows the Risk Priority Number (RPN) methodology [10].

Figure 3 : Risk Priority Number

The RPN (Risk Priority Number) is the product of Severity, Occurrence and Detection (RPN = S x O x D), and is often used to determine the relative risk of a FMEA line item. In the past, RPN has been used to determine when to take action. RPN should not be used this way. RPN is a technique for analyzing the risk associated with potential problems identified during a Failure Mode and Effects Analysis. RPN = Severity Rating x Occurrences Rating x Detection Rating, is the formula used in FMEA.

iii. *Fault Tree Analysis (FTA)*

Fault tree analysis (FTA) is a top down, deductive failure analysis in which an undesired state of a system is analyzed using boolean logic to combine a series of lower-level events. This analysis method is mainly used in the field of safety engineering and Reliability engineering to determine the probability of a safety accident or a particular system level (functional) failure. In Aerospace the more general term "system Failure Condition" is used for the "undesired state" / Top event of the fault tree. These conditions are classified by the severity of their effects. The most severe conditions require the most extensive fault tree analysis. These "system Failure Conditions" and their classification are often previously determined in the functional Hazard analysis. FTA can be used to:

i Understand the logic leading to the top event/ undesired state.

ii Show compliance with the (input) system safety/ reliability requirements.

iii Prioritize the contributors leading to the top event- Creating the Critical Equipment/Parts/Events lists for different importance measures.

iv Monitor and control the safety performance of the complex system (e.g. is it still safe to fly an Aircraft if fuel valve x is not "working"? For how long is it allowed to fly with this valve stuck closed?).

v Minimize and optimize resources. Assist in designing a system. The FTA can be used as a design tool that helps to create (output / lower level) requirements.

vi Function as a diagnostic tool to identify and correct causes of the top event. It can help with the creation of diagnostic manuals / processes.

Many different approaches can be used to model a FTA, but the most common and popular way can be summarized in a few steps. Remember that a fault tree is used to analyze a single fault event and that one and only one event can be analyzed during a single fault tree. Even though the "fault" may vary dramatically, a FTA follows the same procedure for an event, be it a delay of 0.25 msec for the generation of electrical power, or the random, unintended launch of an (Intercontinental Ballistic Missiles) ICBM.

c) Quantitative risk assessment and analysis method

A mooring device is failed when the mooring reaction force *W*, due to oscillation of the floating structure, exceeds the yield strength *R*. The floating structure drifts when all its mooring devices are failed. Failure of a mooring device indicates presence of an event satisfying the following condition:

$$Z_k(t) = W_k(t; X) > 0 \qquad 0 \le t \le T$$

where *X* is natural condition parameters, *T* duration of the natural condition parameters, and R_k the random variable for the final yield strength of mooring device *k*, *X* and R_k are independent of each other. The total reliability for years of service life is approximated by the following equation:

$$R_N(T) = (1 - P_f(T))^N$$

Failure probability for oscillation of the floating structure is

$$[M_{ij} + m_{ij}(\infty)]X(t)'' + F_v(X)' + \sum_{j=1}^{n} \int_{-\infty}^{t} \dot{x}_j(\tau) L_{ij}(t-\tau) d\tau + F_M(X,X) = F_{current}(t)' + F_1(t) + F_2(t)$$

where X: displacement vector of horizontal plane response of the floating structure; M_{ij} :inertia matrix of the floating structure; m_{ij} (∞): added mass matrix at the infinite frequency; F_v: viscous damping coefficient vector; L_{ij} : Memory influence function; F_M: Mooring reaction force vector; $F_{current}$: current load vector, F_1 and F_2: first and second current force vectors respectively. Estimation of wave force vector is generally expressed as the sum of linear wave force proportional to wave height and the slowly varying drift force proportional to the square of the wave height. See the equation below.

$$F(t) = F1(t) + F2(t)$$

$$= \int h_1(\tau)\, \zeta(t-\tau)\, d\tau + \iint h_2(\tau_1, \tau_2)\, \zeta(t-\tau_1)\, \zeta(t-\tau_2)\, d\tau_1\, d\tau_2$$

Where $h_1(\tau)$ $h_2(\tau_1, \tau_2)$ are the vectors of impulse response function of wave force. ζ (t) is the time series of surface elevation of incident waves. Current are considered the dominant impact factor to algae cultivation offshore, Static loads due current are separated into longitudinal load, lateral load. Flow mechanisms which influence these loads include main rope drag, main buoy drag, seaweed drag, and planting lines drag. The general equation used to determine lateral and longitudinal current load are:

$$F = \frac{1}{2}\rho V^2 A\, C_d$$

Floating structure and the pressure drag for the lateral walls. Average wind velocity distribution on the horizontal plane is assumed uniform. The velocity profile in the perpendicular direction expressed using the logarithmic rule. For the fluctuating wind velocity, the mainstream direction (average wind velocity direction) is the sole element of consideration [11].

VII. Assessment of Functional and Serviceability

Modern safety criteria for marine structures are expressed by limit states as indicate in the Table 2 below and are briefly outlined in the following. This will be applied to stages of risk and reliability assessment and analyzing the system required.

Table 2 : Safety Criteria (e.g. ISO 19900 1994, Moan 2004)

Limit State	Description	Remarks
Ultimate (ULS)	• Overall structure stability. • Ultimate strength of structure. • Ultimate strength of mooring system.	(Not relevant for VLFS) Component design check
Fatigue	• Failure of joint-normal welded joins in hull and mooring system.	Component design check depending on residual system strength after fatigue failure.
Accidental collapse (ALS)	• Ultimate capacity of damaged structure (due to fabrication defects or accident loads) or operational error.	System design check
Serviceability (SLS)	• Structure fails its serviceability if the criteria of the (SLS) are not met during the specified service life and with the required reliability	Disruption of normal use due to excessive deflection, deformation, motion or vibration.

The analysis on quantitative analysis is progress; the analysis is done to obtain probability of exceedance, system and mooring reaction relative to annual maximum current velocity, extreme wave return period, maximum mooring force and strength while the reliability will determined the mean current, conditional probability of failure and eventual determination of variation of failure probability and acceptable number of mooring required for the system [12].

VIII. Cost Analysis

Risk control measures are used to group risk into a limited number of well practical regulatory and capability options. Risk Control Option (RCO) aimed to achieve (David, 1996):

i. Preventive: reduce probability of occurrence

ii. Mitigation: reduce severity of consequence

Total cost = present value of future cost + Cost of protective measure

(Cc) = Co +Cc

The cost effective risk reduction measures should be sought in all areas. It is represented by followed:

Acceptable quotient = Benefit/ (Risk /Cost)

IX. Result and Discussion

a) Preliminary Hazard Analysis

Risk analysis is less commonly used to achieve successful and sustainable aquaculture by assessing the risks to aquaculture posed by the physical, social and economic environment in which it takes place.

Table in appendix provide general risk for aquaculture, this include environmental risks (e.g. due to poor siting or severe weather events), biological risks (infection by pathogens via transfer from native stocks, predation by seals and sharks; red tides etc.), operational risks (poor planning, work-related injuries), financial risks (e.g. market changes, currency fluctuations, emergence of new competitors, etc.) and social risks (negative image and resulting product boycott, lack of skilled manpower, competition from other sectors). Table given in the appendix represent result of preliminary hazard analysis whose matrix is given in Figure.

3.1 Checklist

Table 3 : Risk to the System

	Potential Risk	Likelihood L-M-H	Impact L-M-H	Score 1-10	Measures required to control risk
1) Anchor and Mooring System					
▪ Corner buoy ▪ Position anchor ▪ Position sinker ▪ Adjustment anchor ▪ Adjustment outer sinker ▪ Corner mooring rope ▪ Position mooring rope ▪ Adjustment mooring rope ▪ Position buoy ▪ Adjustment buoy	▪ Fatigue ▪ Failure ▪ Sink Collapsed ▪ Damage ▪ Corrosion (internal or external) ▪ Decayed ▪ Destroy by surrounding ▪ Unsuitable materials ▪ Unsuitable size ▪ Not enough number of anchor, buoy, or sinker	H	H	9	▪ Use fabricate concrete block for the anchors. ▪ Use fabricates drum shape concrete for sinkers. ▪ Use PE rope (uv resistant) for ropes. ▪ Use A3 inflatable buoy (60 kg buoyancy) for medium buoy or A1 inflatable buoy (15 kg buoyancy) for small buoy.
2) Frame and Boundary					
▪ Frame rope ▪ Boundary rope ▪ End boundary rope	▪ Inadequate rope ▪ Break ▪ Fatigue ▪ Unsuitable frame design	M	M	6	▪ Inhouse design, fabricate rope with floats and loops. ▪ Use PE rope (uv resistant) for ropes.
3) Buoy					
▪ Corner buoy (large) ▪ Intermediate buoy (medium)	▪ The size and buoyancy.	H	H	8	▪ Use A5 inflatable buoy (180kg) for large buoy and A3 inflatable buoy (60 kg) for medium buoy.
4) Connector					
▪ Buoy shackle (XL)	▪ Types of connector	L	L	3	▪ Use stainless steel
▪ Sinker shackle (M) ▪ Line shackle (M) ▪ Boundary sinker shackle (M)	▪ The uses of them ▪ Loss ▪ Hard to get ▪ Maintenance				shackle. ▪ Used as a connecting link in all manner of rigging systems.
5) Planting Line					
▪ Planting rope ▪ Web rope ▪ Clipper ▪ Adjustment buoy	▪ Loose ▪ Slack rope ▪ Too heavy ▪ Cannot float ▪ Arrangement	M	M	7	▪ Inhouse design, fabricate rope with floats and inserted planting twine ▪ Use connection rope. ▪ Use stainless steel clipper. ▪ Use Molded float (20kg buoyancy)

6) Floating Platform					
▪ Platform ▪ Position anchor ▪ Mooring rope ▪ Adjustment buoys ▪ Sinkers	▪ High cost ▪ Unnecessary ▪ Collapsed ▪ Need more people to work	L	L	3	▪ 15 mt timber, 300 used drum, steel room with canvas, wind/solar power set. ▪ Use PE rope (uv resistant). ▪ Use A3 inflatable buoy (60kg buoyancy). ▪ Fabricate drum shape concrete.
7) Environment					
▪ Wind ▪ Wave ▪ Current ▪ Speed direction ▪ Type of soil ▪ Tide level ▪ Depth of sand ▪ Seabed	▪ Including normal to extreme wind ▪ The wave height ▪ The maximum speed of the current ▪ The direction of speed came from ▪ The highest tide and the low tide ▪ Type of soil underneath the sea ▪ The maximum depth of sand layer ▪ Rocky seabed, debris in the seabed, exposed sharp edge	H	H	9	▪ Design the best system can withstand all types of condition. ▪ Analysis the system before applies it. ▪ Do a test as many as could until the maximum force that the system can stay.
8) Design					
▪ Inappropriate design ▪ Configuration ▪ Structure ▪ Structural integrity	▪ Poorly designed, constructed and maintained farms are more likely to pose a hazard to navigational safety. ▪ The shape, system, components can it hold the system ▪ Failure ▪ Fatigue ▪ Collapsed ▪ Corrosion ▪ Incompatible between the system ▪ Connection	H	H	9	▪ Have alternative design. ▪ Have connection. ▪ Each component and system must have their own uses. ▪ Full detailed. ▪ Have interaction between each component and system.
9) Cost					
▪ Deployment (system, platform) ▪ Transporter (PVC pipe raft, outboard engine) ▪ Theft ▪ Predator	▪ High cost (PVC pipe and accessories, dyneema line, wood platform and workmanship) ▪ Maintenance ▪ Overcome the lost ▪ Uncontrollable	L	L	2	▪ Sea deployment cost. ▪ Avoid from human being want to steal the seaweed. ▪ Avoid treat from turtle or any animals that eat seaweed.

10) Location					
▪ Setiu, Terengganu	▪ The incorrect positioning of this system can increase their potential as a navigational hazard both through their geographical positioning with regard to other users of marine areas, and their physical positioning and size with respect to currents and sea states	H	H	8	▪ Site visit. ▪ Do research and analysis.
11) Natural Disaster					
▪ Tsunami ▪ Swirl ▪ Hurricane ▪ Heat Wave	▪ The natural disaster is unpredictable, when occurs may collapsed all system	L	L	1	▪ Cannot change anything when they happen. ▪ Backup plan.
12) Pollution					
▪ Water pollution	▪ May the system effect /harm the sea water	L	L	1	▪ Totally could not harm the sea water. ▪ 100% environmental friendly
13) Seaweed					
▪ Long lasting ▪ Suitable type	▪ Can stand long time in sea water. ▪ The right type of seaweed that have many functions and give benefits	L	L	2	▪ Multi-functions purpose. ▪ Suggested type of seaweed.
14) Human					
▪ Error ▪ Failure	▪ Installation ▪ Procedure to farm the seaweed ▪ Inconsistency	M	M	7	▪ Certificate crew. ▪ Competence crew.
15) GHG					
▪ Global warming	▪ Release the greenhouse gas	L	L	3	▪ Check with methodology department.
16) Manual					
▪ System	▪ Always take a look the system, site visit	L	L	3	▪ Certificate crew. ▪ Competence crew.
17) Operation					
▪ The system cannot function	▪ Make sure the system is function	M	M	7	▪ Certificate crew. ▪ Competence crew.

Table 4 : Risk from the System To The Outside

	Potential Risk	Likelihood L-M-H	Impact L-M-H	Score 1-10	Measures required to control risk
1) Ecology					
▪ Habitat ▪ Organism	▪ May affect the ecosystem of living organism under sea water	L	L	9	▪ Research what type of organism living under sea water.
2) Passing vessel/ Navigation					
▪ Ships ▪ Ferries ▪ Fishing boats	▪ Disturb the sea traffic	H	H	9	▪ Link with Marine Department to know the scheduled.
3) Health					
▪ Medicine	▪ Good for supplement ▪ People use to cure sickness and disease	M	M	6	▪ Benefit to community.
4) Human					
▪ Systematic system for human	▪ Easy to farm seaweed in a proper way ▪ More seaweed we farm	H	H	10	▪ Can supply the raw material to the government.

b) Fault Mode and Effects Analysis

According to FMEA analysis the top potential modes for this system after we define are anchor and mooring system, environment, design, cost, buoy and location. For anchor and mooring system requirement, the severity almost reaches the highest mark which is 9 marks, but for occurrence and detection they are 8 and 7 marks respectively. That brings 504 Risk Priority Numbers.

Table 5 : FMEA

nents	Potential Failure Mode	Potential Effects of Failure	Severity (1-10)	Potential Cause(s) of Failure	Occurrence (1-10)	Current Controls	Detection	Risk Priority Number (RPN)	Recommended Action	Revised Severity (1-10)	Revised Occurrence (1-10)	Revised Detection (1-10)	Revised Risk Priority Number
nd	▪ Corner buoy ▪ Position anchor ▪ Position sinker ▪ Adjustment anchor ▪ Adjustment outer sinker ▪ Corner mooring rope ▪ Position mooring rope ▪ Adjustment mooring rope ▪ Position buoy ▪ Adjustment buoy	▪ Fatigue Failure ▪ Sink Collapsed ▪ Damage ▪ Corrosion (internal or external) ▪ Decayed ▪ Destroy by surrounding ▪ Unsuitable materials ▪ Unsuitable size ▪ Not enough number of anchor, buoy, or sinker	9	• Environmental loading • Wrong position buoy • Wrong position anchor • External forces • Wrong design • Estimation of the mooring	8	▪ Use fabricate concrete block for the anchors. ▪ Use fabricates drum shape concrete for sinkers. ▪ Use PE rope (uv resistant) for ropes. ▪ Use A3 inflatable buoy (60 kg buoyancy) for medium buoy or A1 inflatable buoy (15 kg buoyancy) for small buoy.	7	504	• Choose the suitable material and high quality to prevent any unwanted accidents or failure occurs.	5	5	4	100

For environment requirement, like wave, wind, current, and seabed the severity number is 9 marks same with detection and the occurrence is 8 marks. So, the RPN is 648. Furthermore, for design requirement for example the inappropriate design, configuration, structure integrity make the severity number is 9 marks share the marks with detection while occurrence is 8 marks, from that, the RPN is 648 same with environment. Moreover, the costs also contribute the biggest potential modes for this system like system deployment. The severity number for the cost is 9 marks, the occurrence is 8 marks and the detection is 7 marks, that make the RPN is 504. Besides that, for buoy and location requirements are also very important. For buoy like corner buoy and intermediate buoy make the severity number is 8, the occurrence number is 7 and detection number is also 8 marks. So the RPN is 448. Meanwhile, the selection for the location is playing the strong point. For the severity it achieves 8 marks same with occurrence, and the detection is 7 marks. From that, the RPN is 448. There are also having another potential modes failure for example frame and boundary, connector, planting line, floating platform, natural disaster, pollution, seaweed, human, manual, operation, ecology, passing vessel or navigations and health. But, they only score medium and low marks for severity, occurrence and detection. As summarize, the most potential modes failure are environment and design. While anchor and mooring system with cost below them and followed by location and buoy. From that, in quantitative analysis we focus more on environment, cost and mooring system. Table 5 show risk matrix for likelihood (from checklist) and severity (FMEA).

Table 5 : Risk Matrix

Risk Rating = Likelihood x Severity

Risk Rating		Severity (FMEA)									
		1	2	3	4	5	6	7	8	9	10
Likelihood(Cheklist)	10	10	20	30	40	50	60	70	80	90	100
	9	9	18	27	36	45	54	63	72	81	90
	8	8	16	24	32	40	48	56	64	72	80
	7	7	14	21	28	35	42	49	56	63	70
	6	6	12	18	24	30	36	42	48	54	60
	5	5	10	15	20	25	30	35	40	45	50
	4	4	8	12	16	20	24	28	32	36	40
	3	3	6	9	12	15	18	21	24	27	30
	2	2	4	6	8	10	12	14	16	18	20
	1	1	2	3	4	5	6	7	8	9	10

Likelihood	*	Severity
0-2 Zero to very low		0-2 No injury or illness
3-4 Very unlikely		3-4 First aid injury or illness
5-6 Unlikely		5-6 Minor injury or illness
7-8 Likely		7-8"Three day" injury or illness
9-10 Very Likely		9-10 Major injury or illness

Score	Action to be taken
0-16	No further action needed.
20-36	Appropriate additional control measures should be implemented
42-100	Work should not be started or should cease until appropriate additional control measures are implemented

c) Fault Tree Analysis

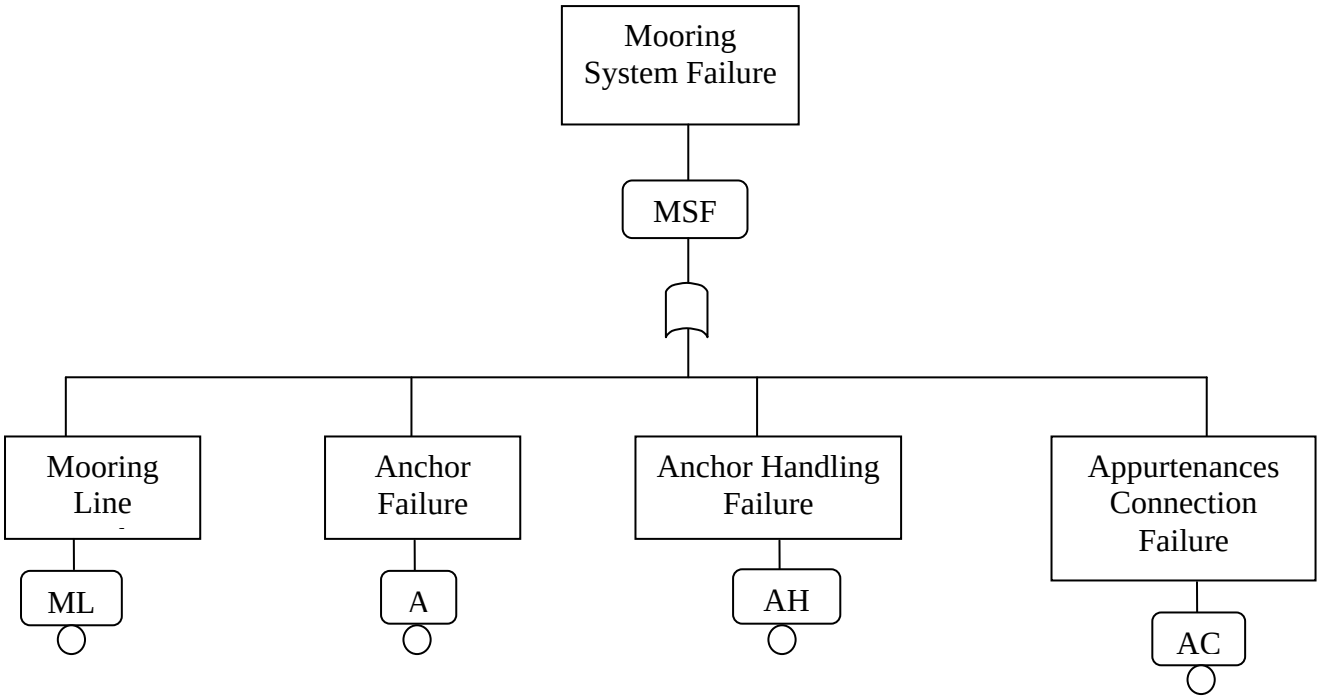

Figure 4 : FTA

MSF = MLB ∪ AF ∪ AHF ∪ ACF
= MLB + AF + AHF + ACF

Table 6 : The cut set of MLB

Rank	Cut Set	Order	Important Level
1	EWa, EWi, ECu	3rd	0.037
2	AEC	1st	0.003
3	NH	1st	0.0023
4	HE	1st	0.0009
5	EF	1st	0.0006
6	MF	1st	0.0006
7	UC	1st	0.0004
8	IC	1st	0.0004
9	ESE	1st	0.0001
10	RS, DiS	2nd	0.0000027
Probability of MLB			0.0453027

Table 7 : The cut set of AF

Rank	Cut Set	Order	Important Level
1	EWa, EWi, ECu	3rd	0.037
2	AEC	1st	0.003
3	NH	1st	0.0023
4	HE	1st	0.0009
5	EF	1st	0.0006
6	MF	1st	0.0006
7	DE	1st	0.0005
8	UC	1st	0.0004
9	IC	1st	0.0004
10	IQC, PRM	2nd	0.0000015
Probability of AF			0.0457015

Table 8 : The cut set of AHF

Rank	Cut Set	Order	Important Level
1	EFoW	1st	0.004
2	IWMS	1st	0.004
3	UAM	1st	0.003
4	HE	1st	0.0009
5	DE	1st	0.0005
6	IC	1st	0.0004
7	UC	1st	0.0004
Probability of AHF			0.0132

Table 9 : The cut set of ACF

Rank	Cut Set	Order	Important Level
1	EWa, EWi, ECu	3rd	0.037
2	AEC	1st	0.003
3	HE	1st	0.0009
4	IDC	1st	0.0007
5	IMS	1st	0.0005
6	UC	1st	0.0004
7	UE	1st	0.0004
8	IC	1st	0.0004
9	WM	1st	0.0003
10	ME	1st	0.0002
Probability of ACF			0.0438

Minimal cut expression for the top event

$T = C_1 + C_2 + C_3 + \ldots\ldots + C_N$

$T = C_{AF} + C_{MLB} + C_{ACF} + C_{AHF}$

$= 0.0457015 + 0.0450327 + 0.0438 + 0.0132$

$= 0.1480042$ per year.

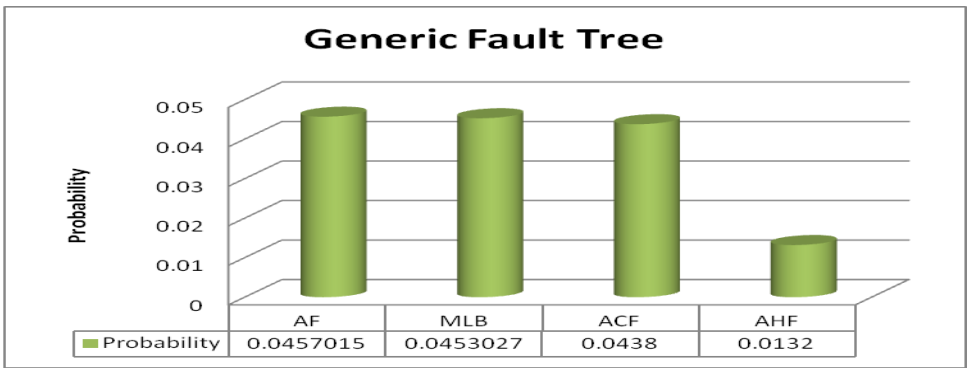

Figure 5 : Fault three analysis summary

From the calculation of minimal cut set it is found that the probability of top event mooring system failure is 0.1480042 per year, in terms of frequency index it is classified as reasonably probable. The graph shows the most critical event in mooring system failure is due to anchor failure (AF) with the probability 0.0457015 per year. The second critical event is mooring line break (MLB) 0.0453027 per year, followed by appurtenances connection failure (ACF) 0.0438 per year, and anchor handling failure with probability (AHF) 0.0132 per year.

X. Conclusion

An integrated approach to risk analysis will assist the aquaculture sector in reducing risks to successful operations from both internal and external hazards and can similarly help to protect the environment, society and other resource users from adverse and often unpredicted impacts. This could lead to improved profitability and sustainability of the sector, while at the same time improving the public's perception

of aquaculture as a responsible, sustainable and environmentally friendly activity. There exists, considerable scope to develop and expand the use of risk analysis for the benefit of aquaculture and the social and physical environments in which it takes place. Design based on risk continue to be a best practice in many industry such as offshore, nuclear, airline, power plant and others where occurrence of accident is unacceptable. Offshore platform design has been successful because of risk approach to design. The maritime industry has adopted risk based design for reliability of marine system in order avoids accident that can lead to Loss of life Loss of property, Loss of money and Destruction of environment. The result of quantitative risk will be provided in other paper. The quantitative risk analyze the risk, system functionality and capability of offshore aquaculture for seaweed plantation for mooring structure and also estimate the risk in design mooring structure and deployment of very large floating structure for oceanic aquaculture seaweed plantation.

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Appendix

Societal risk imposed from aquaculture

Environmental risks	Biological risks	Financial risks	Safety
• pollution from feeds, drugs, chemicals, wastes • alteration of water currents & flow patterns	• introduction of invasive alien species, exotic pests & pathogens • genetic impacts on native stocks • destruction/modification of ecosystems and agricultural lands (mangrove deforestation, salination of ricelands)	• failure of farming operations • collapse of local industry/sector Social risks • displacement of artisanal fishers Human health risks • food safety issues	Mooring failure Risk

Table : Risks to aquaculture from society and the environment

Environmental risks	Biological risks	Operational risks	Financial risks	Social risk
• severe weather patterns • pollution (e.g. agricultural chemicals, oil spills)	• pathogen transfer from wild stocks • Local predators (seals, sharks etc.) • toxic algal blooms, red tide	• poor planning • poor design • workplace injuries	• market changes • inadequate financing • currency fluctuations • emergence of new competitors	• negative image/press • lack of skilled manpower • competition for key resources from other Sectors •theft, vandalism

Global Journal of Science Frontier Research
Environment & Earth Science
Volume 13 Issue 1 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Pilot Study for Quantification of Emissions of Green House Gas for Decision Support towards International Maritime Organization (IMO) Rule Making

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GJSFR-H Classification : FOR Code: 829801

Strictly as per the compliance and regulations of :

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Abstract - The shipping industry is responsible for the carriage of 90% of world trade. Thus, it remains the most energy efficient mode of transport. Shipping is expected to have greater impact on global warming considering size of vessel plying the world ocean. The Green House Gas (GHG) emissions are the main air pollutants in maritime transportation. In 2007, CO_2 emission from the shipping amounted to 847 million tones or about 2.7% of global CO_2 emission and it is expected to reach 18% in 2050. In July 2009, Marine Environment Protection Committee (MEPC) approved to circulate interim guidelines on the method of calculation of Energy Efficiency Design Index (EEDI) to create stronger incentives for further improvements in ship's fuel consumption, resulting CO_2 emissions on a capacity basis. This paper present outcome of GHG emission data collection and quantification from ship, the study hope to contribute to regulation for reduction of GHG emission in shipping industry and subsequent mitigation of climate change. Equipment used to measure the concentration of gas and total suspended particulate in the atmosphere are Mini Vol Portable Air Sampler, Graywolf Direct Sense Monitoring Kit, TSI IAQ-Calc and Gas Detector IQ-1000. The equipment's are used to determine the gas concentration, nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon dioxide (CO_2) concentration respectively. Carbon dioxide (CO_2) is the most important anthropogenic GHG. The experimental data analysis is used to validate recommended EEDI calculation.

Keywords : emissions, international maritime organization (IMO), green house gas (GHG), vessel, bidong island, GHG, emission, ship, IMO, EEDI, climate change.

I. Introduction

Air pollution is the on demand case as it has been debated all over the world. The sources of air pollution vary, starting from the individual pollutants to the huge industry activities. Maritime industry is responsible for part of Green House Gas Emision pollution, since there are many types of maritime transports sailing and maneuvering at the sea. The Green House Gas (GHG) emissions from maritime transport must be reduced because it is expected to increase if no mitigations are taken. This paper discusses the result of exhaust emission quantification for University Malaysia of Terengganu (UMT) vessel (Discovery II). The experiment analysis two types of gas, Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2).The is a pilot study in preparation for data collection on larger ships. The pilot study involves sailing from Pengkalan Arang Jetty to Bidong Island and it is divided into two modes, maneuvering mode and hoteling mode.

The international shipping is considered the most carbon efficient mode of commercial transport and generally considered as an environmentally friendly means of transportation. This help shipping economy of large scale, as a result of this, maritime and shipping industry experience rapid development and the number of vessels sailing in the ocean continues to increase. However, the significant improvements that have taken place in these industries lead to the increasing of Green House Gas (GHG) considering the large involve of vessel that sail the world ocean. The use of hydrocarbons and their derivatives as fuel contributes to air pollution. The amount of emissions depends on the design, operating conditions and the characteristics of the fuel. Complete combustion of fuel leads to the exhaust that contains only Carbon Dioxide (CO_2) and water vapor. Carbon Dioxide (CO_2) emission depends on fuel consumption and carbon content in the fuel.

Some factors that influencing emission are cold starts, speed, maintenance, engine design and fuel used [1]. The most troublesome GHG emission from diesel engine is NOx and soot (particulates). The black smoke observed from certain ships or boats are due to high carbon particles content and it is obvious during rapid load increase and when older engine at high load. As a response towards the GHG emissions problem, another dimension has been added to the ship's design and operational practices. The improvement in design includes the propeller, hull, superstructure and use of retrofitting system for machineries (exhaust gas after

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filter, humidification, exhaust gas recirculation, electronics injection and lubrication. For the operational practices, the maintenance of the ships are to ensure that ship follow the schedule and guidelines and also by slowing the speed of the ship during at sea as well as cold ironing. Other option being adopted is alternative energy and hybrid concept.

This study focuses on the emissions concentration of Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2) that are released from the exhaust of Discovery II. The emissions concentrations are measured by using the Gas Detector IQ-1000. The RV Discover II started sailing to Bidong Island at initial speed 6 knots and continue at speed 12 knots during at sea. The distance of Bidong Island from Kuala Terengganu is 40km. Table 1 show the principal particulars of the Discovery II that has been operated in 12 years.

Table 1 : The principal particulars of Discovery II

Length overall	16m
Breadth	4.05m
Depth	2.15m
Fuel	4000L
Fresh water	1000L
Main engine	300HP/1800RPM
Speed (design)	12 knots
Cruise speed	10knots
Gross tonnage	43T
Net tonnage	16.82T

The experiment is divided into two which are maneuvering mode and hoteling mode. The hoteling mode data is recorded near Bidong Island so that the data is not influence by the land activities.

II. Background

The quests for an efficient fuel friendly to the environment have been recognized in maritime industry for a long time. Need for improvements of gasoline and diesel by chemical reformulation that can lead to decrease in GHG release and ozone forming pollutants and carbon monoxide emissions have become issues of the time. Beside this, machineries that cannot use such conditional and additional inconvenience posed by these reformulation chemicals are subject to performance problems like cold start ability, smooth operation and avoidance of vapor lock.

Emission from combustion impacts generation of fossil fuel scarcity, photochemical smog, and oil dependent world. Aggressive quest for alternative energy, international and local regulation build-up as well as reassessment and revolution work on plan to reduce emission of existing and new engine are faced with new challenge of matching energy efficiency at minimum emission. Pollution control of emission is linked to traditional factors of reliability, fuel economy per shaft power, capital cost and maintenance. Maximizing overall energy efficiency that includes performance of temperature, electrical, thermodynamic and mechanical as well insulated boiler system to achieve combustion efficiency close to 100% and thermal efficiency of the order of 90% has a ways been the drive of the time for new low pollution and high efficiency technology. Technology try to recuperate or prevent heat loss by high temperature exhaust gas and in coolant systems reduces the thermal efficiency [6].

For marine electrical energy, technology is after 70 percent of the primary energy that is lost in the power generation & transmission stage, while thermal efficiency improvement sough insulation, recycling of gaseous effluents, rate of heat transfer in combustion chamber and liquid coolants. Designer of combustion chamber aim to achieve high combustion efficiency as unburnt fuel is considered to be pollutants, this create new directions for new engine and retrofit system for existing engines. The issue of emission compliance is a disguise blessing of doubles incentive opportunity for humanity to develop complete combustion efficiency and reduces emission. A good combustion require high temperature, a resident time sufficient long, present of oxidizer heat transfer from flame to solid surface that compose of conduction, convection and radiation luminosity and present of solid particles that can lead to significance change in ratio of radioactive to convective heat transfer.

Problem associated with achieving maximum efficiency are linked to pollution control, complete oxidation and burning of fuel, combustion efficiency and pollution prevention. However, oxide of nitrogen presents major problems due to contradictory requirement of pollutant formation and combustion efficiency, because, formation of oxides of nitrogen has affinity to high temperature. Compare to formation sulfur, control require removal of sulphur before burning or extraction from effluent before send it for combustion task.

III. Global Warming and its Impact

Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily, due to the greenhouse gases released of exhaust waste from burning fossil fuels. The current climatic warming is occurring much more rapidly than past warming events. In Earth's history before the Industrial Revolution, Earth's climate changed due to natural cause unrelated to human activity. These natural causes are still in play today, but their influence is too small or they occur too slowly to explain the rapid

warming seen in recent decades. Models predict that as the world consumes more fossil fuel, greenhouse gas concentrations will continue to rise and Earth's average surface temperature will rise with them. Based on plausible emission scenarios, average surface temperatures could raise between 2°C and 6°C by the end of the 21st century. Some of this warming will occur even if the future of greenhouse gas emissions are reduced, because the Earth system has not yet fully adjusted to environmental changes that is currently being experienced.

The "greenhouse effect" is the warming that happens when certain gases in Earth's atmosphere trap heat. These gases let in light but keep heat from escaping, like the glass walls of a greenhouse. The sunlight shines onto the Earth's surface, where it is absorbed and then radiates back into the atmosphere as heat. In the atmosphere, "greenhouse" gases trap some of this heat, and the rest escapes into space. The more greenhouse gases are in the atmosphere, the more heat gets trapped. Levels of greenhouse gases (GHGs) have gone up and down over the Earth's history, but they have been fairly constant for the past few thousand years. Global average temperatures have stayed fairly constant over that time as well, until recently. Through the burning of fossil fuels and other GHG emissions, humans are enhancing the greenhouse effect and warming Earth.

Some impacts from increasing temperatures that already happened are ice is melting worldwide, especially at the Earth's poles. Besides, the number of penguins on Antarctica has fallen from 32,000 breeding pairs to 11,000 in 30 years. Sea level also rises faster over the last century. Some butterflies, foxes, and alpine plants have moved farther north or to higher, cooler areas. Precipitation (rain and snowfall) has increased across the globe, on average. Spruce bark beetles have boomed in Alaska thanks to 20 years of warm summers. The insects have chewed up 4 million acres of spruce trees.

The ozone layer is a belt of naturally occurring ozone gas that sits 9.3 to 18.6 miles (15 to 30 kilometers) above Earth and serves as a shield from the harmful ultraviolet radiation emitted by the sun. Ozone is a highly reactive molecule that contains three oxygen atoms. It is constantly being formed and broken down in the high atmosphere, 6.2 to 31 miles (10 to 50 kilometers) above Earth, in the region called the stratosphere [7].

The carbon trading came about in response to the Kyoto Protocol. Signed in Kyoto, Japan, by some 180 countries in December 1997, the Kyoto Protocol calls for 38 industrialized countries to reduce their greenhouse gas emissions between the years 2008 to 2012 to levels that are 5.2% lower than those of 1990. A carbon trading system allows the development of a market through which carbon (carbon dioxide) or carbon equivalents can be traded between participants, whether countries or companies. Each carbon credit is equal to one hundred metric tons of carbon dioxide, which can be traded or exchanged in market. There are two kinds of carbon trading which are emission trading and trading in Project-based credits. The two categories are put together as hybrid trading system. Carbon trading is also called pollution trading [8].

The exhaust fumes contain a large number of different chemicals or emissions. Once released into the air, exhaust Emissions are breathed in and transported in the bloodstream to all the body's major organs. Diesel seems potentially to be more of a problem than petrol. Potentially dangerous vehicle emissions include carbon monoxide, nitrogen dioxide, sulphur dioxide and particulate matter. Although research has clearly linked exhaust emissions to a range of health problems in the population, the exact risk to any individual is difficult to define. The most obvious health impact is on the respiratory system. It's estimated that air pollution of which emissions are the major contributor is responsible for 24,000 premature deaths in the UK every year. A Dutch study confirm that, of 632 children aged seven to 11 years found that respiratory disorders worsened as air pollution increased and a longer term study of older Dutch residents, published in 2009 found that illness due to lung disorders increased in areas of high nitrogen dioxide and particulate matter associated with exhaust emissions. Some of the impacts to health due to the emissions are cancer, central nervous system may grow older and blood implication.

a) Green House Gas (GHG) emission from shipping

If global shipping were a country, it would be the sixth largest producer of greenhouse gas emissions. Only the United States, China, Russia, India and Japan emit more carbon dioxide than the world's shipping fleet. Nevertheless, carbon dioxide emissions from ocean-going vessels are currently unregulated. These measures can have an almost immediate effect on emission reductions, and a reduction of 33 percent below the business-as-usual baseline could be attained at no cost. Previous attempts by the industry to calculate levels of carbon emissions were largely based on the quantity of low grade fuel bought by shipowners. The latest UN figures are considered more accurate because they are based on the known engine size of the world's ships, as well as the time they spend at sea and the amount of low grade fuel sold to shipowners. The UN report also reveals that other pollutants from shipping are rising even faster than CO_2 emissions. A spokesman for the Department for Environment, Food and Rural Affairs said the government would support the development of a global emissions trading scheme through the IMO, and was also "investigating the feasibility of including maritime emissions" in the EU's trading scheme. He said the shipping industry must take its "share of responsibility" for tackling climate change.

b) Imo and GHG Emission

According to the Second IMO GHG Study 2009, the level of GHG emitted by international shipping was estimated to have 870 million tones or about 2.7% of the global man made emission of COx in 2007. Exhaust gases are the main source of GHG emissions from ships and COx is the most important GHG that contribute to global warming. The COx emission is expected to increase to 6% in 2020. If no mitigation measures are taken, it can increase to 250% in 2050. Figure 1 showed the exhaust emissions from shipping industry between 1997 and 2007.

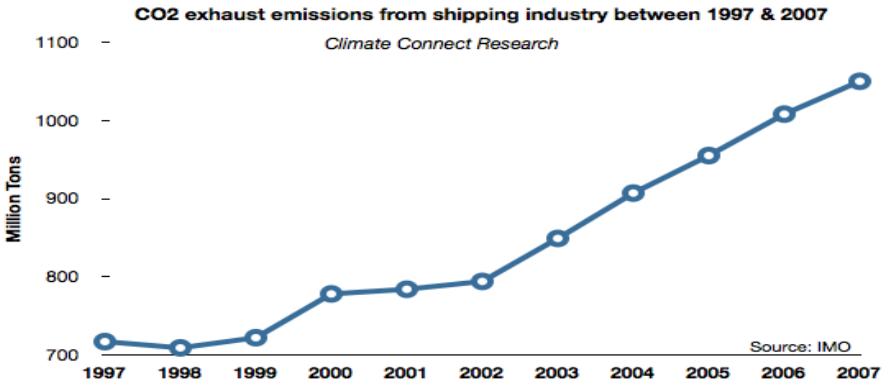

Figure 2 : CO2 exhaust emissions from shipping industry between 1997 and 2007

Figure 2 revealed one of the reason, regulatory institution for stepping up the On July 2011, International Maritime Organization (IMO) adopted a new chapter to MARPOL annex VI which is to reduce GHG emission from international shipping by improving the energy efficiency for ships. The hull design, propulsion techniques and operational practices are expected technology that can be improved in order to increase the energy efficiency for ships. The Marine Environment Protection Committee (MEPC) approved the interim guidelines on the method of calculation of Energy Efficiency Design Index (EEDI) towards determining minimum energy efficiency level for new ships. It is apply to all merchant ships of 400 gross tonnages and above regardless of the national flag the fly or the nationality of the owner [5].

Emission is inherent consequence of powered shipping, fuel oil burning as main source of continuous combustion machineries like boilers, gas turbines and incinerators. GHG emission is closely linked to machineries combustion. For a long time environmental issues in shipping has focused more on release to water, only lately release to air and soil has become serious issue of concern because of pressure from climate change impacts. Shipping is still considered far less emission pollutant compare to other mode transportation, but a thorough analysis on the volume ship and risk impose to the ocean media that support all activities on earth pose a big question on the actual quantity of emission. However, since environment differs, so are the impact and the presence of pollutants, thus they are dependent on the volume of shipping traffic. Yet the science of transportation of atmospheric gas dictates more about need for the whole world to work together. Recent IMO resolution on these mandated nations to collect data on emission so that reliable compliance measures can be incorporated into annex of MARPOL in order to meet the requirement for Energy Efficiency Design Index (EEDI), Ship Energy Efficient Management Plan (SEEMP) and Ship Energy Efficiency Operational indicator (SEEOI). Study of emission from ship has not been fully initiated or studied in Malaysia.

The purpose of this multidiscipline research project is therefore to record and analyse the different Green House Gas Emison from boat, ships, near or within the vicinity of port, inlandwater port areas, shipping lanes in order to determine the characteristics and source of emison at different locations for require rule making and decisuon support for choice of environmental prevention and contriol technology. Table 2 shows Inland waterways environmental performance in European waters concluded the following.

Table 2 : Emission reduction potential

	NOx	PM	FC	Cox	Sox
	%	%	%	%	%
After treatment					
SCR (Selected catalytic reduction)	-81	-35	-7.5	-7.5	-7.5
PMF (Particulate matter filter)	None	-85	2	2	2
Drive management systems					
ATM (Advising temporal)	-10	-10	-10	-10	-10
Diesel fuel quality / substitutes					
(BD) Bio – Diesel	-10	-30	15	65	~-100
BDB (Biodiesel blend , 20%BD)	2	-6	3	-13	~-20
LSF (Low sulfur fuel)	None	-1.7	none	None	~-100
New engine technology					
NGE (Natural Gas Engine)	-98.5	-97.5	4.5	-10	-100

IV. Methodology

a) Study Location

Thus, there are recent GHG gas emission quantification in other part of the world, but the data are hard to to be applied to pother region, because, reliability of environmental research require localization. RV Discovery II is sailed from Pengkalan Arang Jetty to Bidong Island. The data is collected during its saling, maneuvering and hoteling mode, the data is recorded near to the Bidong Island that is far from the land. Therefore, the concentration of gases recorded by the equipment is mainly coming from the vessel engine. Data information related the following are used:

- Emission factors for each components air emission factors for air is established by regulatory bodies
- Fleet information on board data based ship performance information
- Ship operational data (power consumption, speed time at sea)
- Shipping movement information from different source within fleet that call Malaysia and European ports
- Analysis will be made for contribution by vessel and operations

b) Equipment

The equipment used for collecting the concentration of gases is the Gas Detector IQ-1000. It can detect over 100 toxic and combustible gases using a single sensor. The calibration is automated with no manual adjustments necessary. The power is provided by 6 'D' size alkaline or nickel cadmium batteries. The data that is successfully recorded is displayed on the unit and stored in data acquisition system and then transferred to through the RS 232 computer port or send to printer for further analysis.

This equipment is placed on the safe and balance area near the exhaust of Discovery II. The sensor is then pointed 20 cm away from the exhaust hole. The setting of the equipment is changed by selecting three types of gases, Carbon Dioxide (CO_2), Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) as parameters that are going to be measured. The procedure of using the Gas Detector IQ-1000 is as followed:

i. AC power supply is connected to the unit.
ii. Sensor is connected to the unit.
iii. Gas detector IST IQ-1000 is turned on by pressing the POWER button and waits until the reading appeared at every sensor.
iv. The pump is turned on by pressing the PUMP button.
v. The LOG DATA button is pressed to record the data.
vi. The LOG DATA and PUMP are turned off after the sampling is finished.

Figure 3 shows the experimental setup of the pilot study conducted on Discovery II.

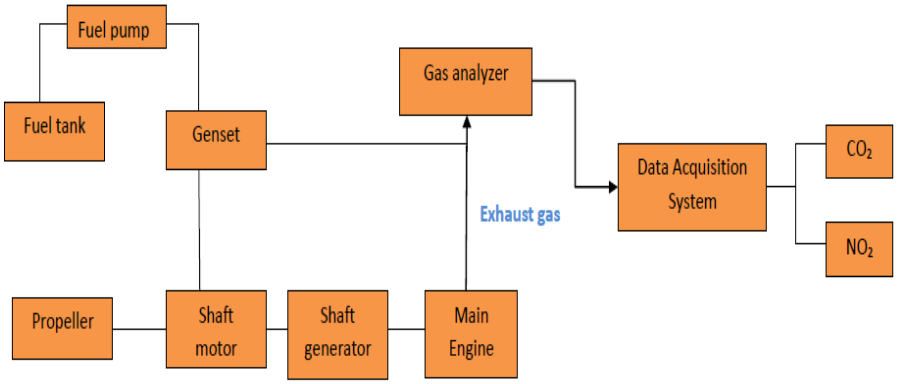

Figure 3 : Experimental Setup

EEOI represent performance index that provides the CO2 level per unit of cargo/passenger moved by unit of distance.

EEOI estimation takes into consideration:

cargo mass term (mcargo) which is expressed as tonnes, TEU, passengers, etc.

- actual fuel consumption (FC).
- carbon factor (CF) selected based on fuel type
- actual distance (D) over ground.
- acceptable damping factor voyage fluctuations and rolling

$$\text{EEOI} = \frac{\sum_j FC_j \times C_{Fj}}{m_{cargo} \times D}$$

EEDI represent combined impact of commercial, operation and technical aspects. Its estimation face challenges related voyage definition, data collection, data quality, bunker consumption uncertainty, sea state conditions, weather, etc. Figure 4 shows the flow chart EEDI calculation for new ships. EEDI values that can be used to calculate overall EEDI for anticipated operations like loaded voyage at a range of operating speeds, ballast voyage at a range of operating speeds, loading alongside and discharge alongside. At design stage EEDI could be used to support decisions for suitability of ships for different trades.

Comparison of EEOI and EEDI define improvement in auxiliary power to more closely represent actual operation. Calm water EEOI values could be compared with EEDI values to assess degradation in performance. Such comparison could also be used to compare different transport modes.

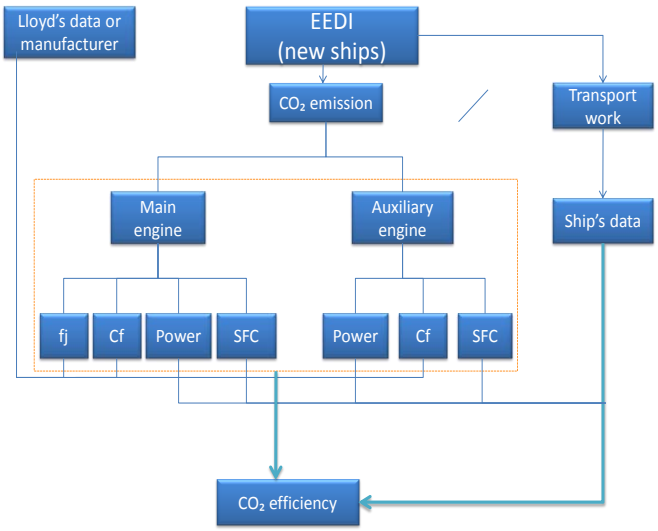

Figure 4 : Research methodology flowchart

EEDI is the abbreviation of Energy Efficiency Design Index. Marine Environment Protection Committee (MEPC) has developed the EEDI formula for new ships in order to require the minimum energy efficiency level for new ships and to stimulate continued technical development of all the components influencing the fuel efficiency of a ship. It also separate the technical and design based measures from the operational and commercial measures as well as enable the comparison of the energy efficiency of individual ships to similar ships of the same size which could have undertaken the same transport work. The EEDI formula provides a specific figure for an individual ship design, expressed in grams of CO per ship's capacity mile (a smaller EEDI value means a more energy efficient ship design) and calculated by a given formula based on the technical design parameters of a given design:

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}*\right) + \left(\left(\prod_{j=1}^{M} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}\right)}{f_i \cdot Capacity \cdot V_{ref} \cdot f_w}$$

Where: ME and AE represent main engine(s) and auxiliary engine(s); P, the power of engine (kW); CF a conversion factor between fuel consumption and CO2 based on carbon content; SFC, the certified specific fuel consumption on the engines (g/kWh); Capacity, the deadweight (tonnes); Vref is the ship speed (knot); and fj is a correction factor to account for ship specific design elements fw is a non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed. fi is the capacity factor for any technical/regulatory limitation on capacity, and can be assumed one (1.0) if no necessity of the factor is granted. The EEDI formula can be simplified to:

EEDI = CO_2 emission / transport work

The CO_2 emission represents total CO_2 emission from combustion of fuel at design stage, including propulsion and auxiliary engines, taking into account the carbon content of the fuels in question. If shaft generators or innovative mechanical or electrical energy efficient technologies are incorporated on board a ship, these effects are deducted from the total CO_2 emission. If wind or solar energy is used to board a ship, the energy save by such measures will also be deducted from the total CO_2 emissions, based on actual efficiency of the system. The transport work is calculated by multiplying the ship's capacity as designed (deadweight for cargo ships and gross tonnage for passenger ships) with the ship's design speed measured at the maximum design load condition and at 75% of the rated installed shaft power. Speed is the most essential factor in the formula and may be reduced to achieve the required index. Table 3 shows necessary input data and assumption.

The nitrogen emission per year can be estimated from;

5.34lb/Hr).(8760hr/year).(ton/200lb)

Where 5.34lb is assumed emission factor

Table 3 : Input Data

Activities	Category	Source
Ship Movements	Data Records for each vessel: vessel type, Previous and current ports, date of movement, etc	Navigation data
Main engine power	Correlations for vessel type and DWT	Navigation data, Marine Department, or Environmental department's
Aux engine power Estimate	using aux/main engine power ratio	From Within Malaysia and European ports
Load factors	by mode Factors	Malaysian ports environmental department best practices methods. Emission factors Entec, 2002, Swedish Methodology for Environmental Data, 2004, Starcrest, 2004, MAN B&W, 2004. Vessel speed Navigation data or default values.
Time underway	Port-to-port distances were estimated individually for 80% of movements. Simplified distance estimates for balance.	Equal to distance/vessel underway speed.

Time manoeuvring	For each vessel type. Includes intraport distances in large ports	Equal to manoeuvring distance/vessel speed
Time hoteling	By vessel type, based on vessel arrival & departure., fuel statistics and emission factors OR trading pattern vessels	Navigation data

IMO SEEMP guidelines are a mechanism for a shipping company to improve energy efficiency of a ship's operation. SEEMP provides guidance for the development of model plan for characteristics and needs of individual companies and ships.

V. Result and Discussion

From three types of gases that have been selected, only two types are successfully detected by the Gas Detector IQ-1000 which is Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2). The data of exhaust emissions are analyzed by using Microsoft Excel and Minitab 15. Table 4 shows the summary of the test when Discovery II starts maneuvering at 6 knots.

Table 4 : The concentration of Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2)

Time (am)	Carbon Dioxide (ppm)	Nitrogen Dioxide (ppm)
9:21:59	0	0
9:22:07	0	0.7
9:22:08	70	4.2
9:22:09	290	8.7
9:22:10	820	13.4
9:22:11	1650	17.5
9:22:12	2000	20
9:22:59	2000	20

Based on the data collected, the graph time versus amount of gas concentration (ppm) is plotted. Figure 5 and Figure 6 shows the graph of the concentration of the Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2) respectively.

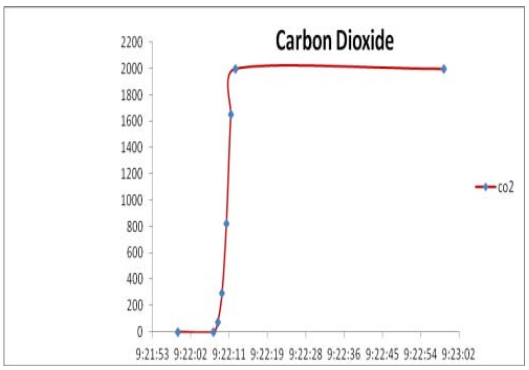

Figure 5 : The concentration of Carbon Dioxide (CO_2) versus time

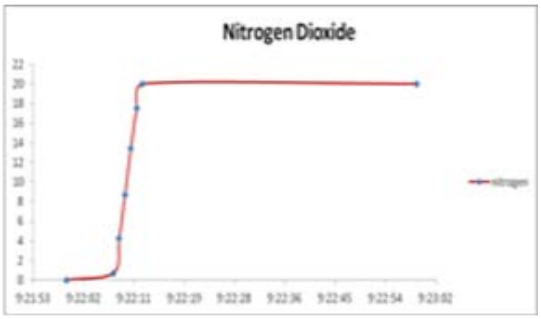

Figure 6 : The concentration of Nitrogen Dioxide (NO_2) versus time

According to the graph for both gases concentration, the reading recorded increasing drastically until they reached the maximum value. This is because; the engine of the boat needs high energy to maneuver at the initial. The maximum reading for Carbon Dioxide (CO_2) is 2000 ppm while for the Nitrogen Dioxide (NO_2) the maximum reading is 20ppm. The Figure 7 and Figure 8 below show the data analyzed by using Minitab 15. The histogram shows acute skew to the left and agreement to the rise in the release of the gas during the experiment.

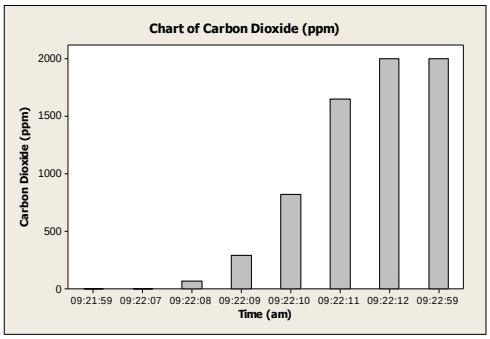

Figure 7 : The concentration of Carbon Dioxide

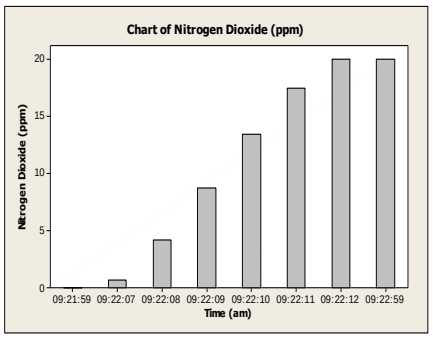

Figure 8 : The concentration of Nitrogen Dioxide

Table 5 shows the summary of the test during Discovery II maneuvering at sea.

Table 5 : The concentration of Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2)

Time (am)	Carbon Dioxide (ppm)	Nitrogen (ppm)
9:57:47	2000	0.9
9:57:50	2000	0.9
9:57:51	2000	1.6
9:57:54	2000	2.1
9:57:55	2000	3.6
9:57:56	2000	6.2
9:57:57	2000	8.8
9:57:58	2000	11.1
9:57:59	2000	13.1
9:58:00	2000	14.9
9:58:01	2000	16.4
9:58:02	2000	17.7
9:58:03	2000	18.7
9:58:04	2000	19.5
9:58:17	2000	20

Based on the data collected, the graph time versus amount of gas concentration (ppm) is plotted.

Figure 9 and Figure 10 show the graph of the concentration of the Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2) respectively.

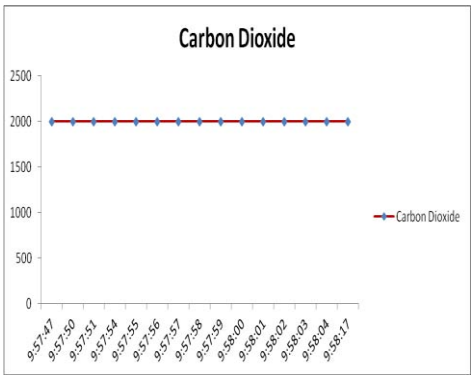

Figure 9 : The concentration of Carbon Dioxide (CO_2) versus time

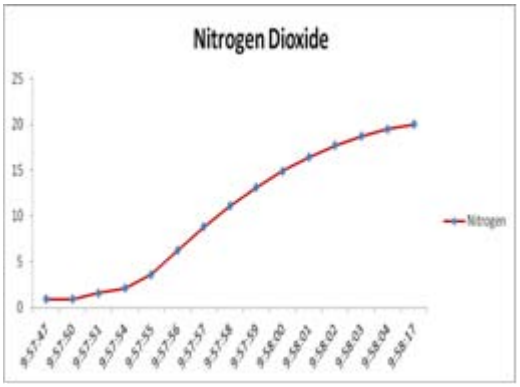

Figure 10 : The concentration of Nitrogen Dioxide (NO_2) versus time

According to the graph, The concentration of Carbon Dioxide become constant at maximum value of 2000 ppm. For the concentration of Nitrogen Dioxide, the graph plotted is smoother than the previous graph, because the vessel starts to sail then. It is increasing slowly at the beginning and continue without drastic until it reach the maximum value. The Figure 11 below shows the data analyzed by using Minitab 15 for Nitrogen Dioxide only. The histogram shows similar trend with previous Nitrogen reading.

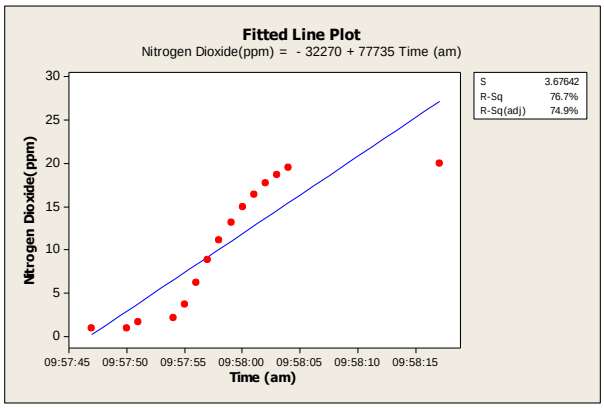

Figure 11 : The concentration of Nitrogen Dioxide

Table 3 shows the summary of the test during Discovery II is in hoteling mode.

Table 6 : The concentration of Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2)

Time (pm)	Carbon Dioxide (ppm)	Nitrogen (ppm)
12:21:52	2000	0.4
12:21:52	2000	0.4
12:21:55	2000	0.9
12:21:56	2000	1.8
12:21:57	2000	2
12:21:59	2000	3.8
12:22:00	2000	6.8
12:22:01	2000	10.1
12:22:02	2000	12.9
12:22:03	2000	15.2
12:22:04	2000	17.1
12:22:05	2000	18.7
12:22:06	2000	20
12:23:10	2000	20

Based on the data collected, the graph time versus amount of gas concentration (ppm) is plotted.

Figure 12 and Figure 13 show the graph of the concentration of the Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2) respectively.

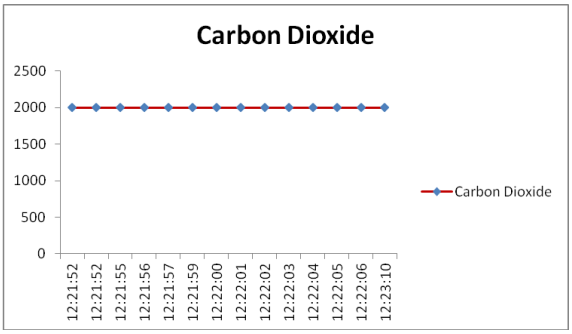

Figure 12 : The concentration of Carbon Dioxide (CO_2) versus time

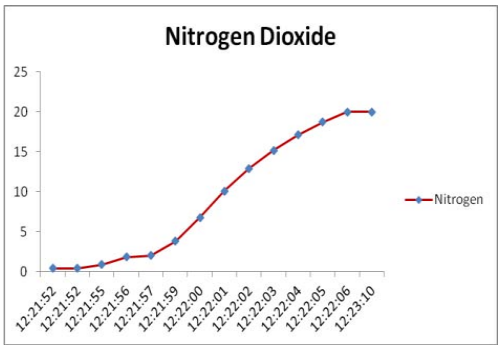

Figure 13 : The concentration of Nitrogen Dioxide (NO_2) versus time

According to the graph, the concentration of Carbon Dioxide (CO_2) still not change and keep consatnt. For the concentration of Nitrogen Dioxide, it is increasing slowly and sometimes constant at the beginning then it continue to increase until it reach maximum value. The Figure 14 below shows the data analyzed by using Minitab 15 for Nitrogen Dioxide only. Similar histogram trend is obtained.

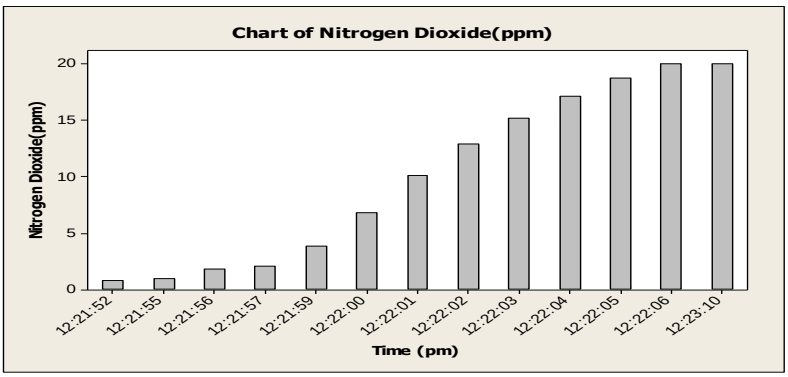

Figure 14 : The concentration of Nitrogen Dioxide

VI. Conclusion

The maximum reading of Carbon dioxide and Nitrogen Dioxide that can be detected by the Gas Detector IST IQ-1000 are 2000ppm and 20ppm respectively. At the initial stage of the experiment, the amount of Carbon Dioxide increased dramatically and it remains constant until the experiment is finished. For the Nitrogen Dioxide, it also increased dramatically at the initial of the experiment and its amount keeps changing and not constant until the experiment is finished. The overall data showed that the Nitrogen Dioxide measured keep changing and not uniform. For the first reading, the data collected finished in 5 seconds while the second reading, third reading and fourth reading finished in 33 seconds, 18 seconds and 8 seconds respectively. For the hoteling mode which is fifth reading and sixth reading, the data collected finished in 25 seconds and 14 seconds respectively. The amount of Nitrogen Dioxide in each data collected is increasing, decreasing and sometimes constant. The data collected in this pilot study is based on the unsophisticated device. The experimental set up is the first experiment we have done in measuring the gas emission. The pilot study is preparation for similar experiment on ocean going vessel, and inadequacy experience in the pilot study will be mitigated for better accuracy.

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Global Journal of Science Frontier Research
Environment & Earth Science
Volume 13 Issue 1 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Soil Colour as a Pedo-Transfer Function of Soil Organic Carbon and Fertility in a Typic Plinthaqualf

By Senjobi, B. A., Adejuyigbe, C. O., Ande, O. T., Oyegoke, C.O. & Ogunkunle, A. O.

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Abstract - The need to guide the land users on the appropriate usage of land and fertility maintenance is very imperative in addressing food sufficiency. Thus, a study was conducted to investigate the erroneous belief by local farmers' that soil colour can effectively predict soil productivity. Three land use types namely: arable cropping (land use 1), oil palm (land use 2), and secondary forest (land use 3) were studied. Profile pits (3 per land use type) were dug at the three predominant land types encountered on the site viz: crest, middle slope, and valley bottom. Soil colour (moist and dry) was determined using the munsell colour chart. The results revealed that pedons at the crest and middle slope are more reddish to brownish while that of valley bottom are greyish. This changes with depth across the soil profiles. The hue varies with land use type, with land use 1 having higher hue at the valley bottom than other land use types. While this decreases as the slope increases in land use 1, the reverse was the trend in oil palm site. However, in land use 3, the hue was generally low at the valley bottom and not as high as in land use 1.

Keywords : *soil colour, pedo- transfer, organic carbon, fertility, typic plinthaqualf.*

GJSFR-H Classification : *FOR Code: 160302, 961499*

Strictly as per the compliance and regulations of :

Soil Colour as a Pedo-Transfer Function of Soil Organic Carbon and Fertility in a Typic Plinthaqualf

Senjobi, B. A.[α], Adejuyigbe, C. O.[σ], Ande, O. T.[ρ], Oyegoke, C.O[ω] & Ogunkunle, A. O.[¥]

Abstract - The need to guide the land users on the appropriate usage of land and fertility maintenance is very imperative in addressing food sufficiency. Thus, a study was conducted to investigate the erroneous belief by local farmers' that soil colour can effectively predict soil productivity.

Three land use types namely: arable cropping (land use 1), oil palm (land use 2), and secondary forest (land use 3) were studied. Profile pits (3 per land use type) were dug at the three predominant land types encountered on the site viz: crest, middle slope, and valley bottom. Soil colour (moist and dry) was determined using the munsell colour chart.

The results revealed that pedons at the crest and middle slope are more reddish to brownish while that of valley bottom are greyish. This changes with depth across the soil profiles.

The hue varies with land use type, with land use 1 having higher hue at the valley bottom than other land use types. While this decreases as the slope increases in land use 1, the reverse was the trend in oil palm site. However, in land use 3, the hue was generally low at the valley bottom and not as high as in land use 1.

In land use 1, the exchangeable bases increase as the hue 10YR – 25YR decreases in the surface soils except for valley bottom soils, where the reverse is the trend.

Organic carbon and exchangeable acidity increases with decrease in hue irrespective of the land type in land use 1. However, phosphorous value decreases as the hue decreases in all the land types, while Zn is constant.

At land use 2, the exchangeable bases except for calcium follow the reverse trend as in land use 1. While organic carbon increases in land use 1, the reverse is the trend in the land use 2, with nitrogen following the same sequence as organic carbon.

Exchangeable acidity, phosphorous and Zinc only decreases with decreasing soil hue in valley bottom soils, and increases in the other land types.

At land use 3, only sodium and potassium increase with decreasing hue (7.5YR – 25YR) at the crest and middle slope sections, while at valley bottom soils the reverse is the trend.

While magnesium increases with decreasing soil hue across the land types, organic carbon, calcium, zinc and copper decreases with decreasing soil hue. Nitrogen, phosphorous and pH KCl as well as exchangeable acidity follow the same sequence with sodium and potassium in land use 3.

It was obvious from the study that soil colour is not a sufficient parameter in ascertaining soil fertility status. Therefore, land use analysis remains the vital tool in assessing fertility status of the soil before optimal and sustainable production can be attained.

Keywords : soil colour, pedo-transfer, organic carbon, fertility, typic plinthaqualf.

I. Introduction

The general erroneous concept of soil fertility status by peasant farmers through the colour of the soil calls for urgent investigation especially at this era of soil pollution. This is because sewage sludge and to some extent heavy metals such as lead (Pb) also constitute to the colour of the soil. Anthropogenic activities as well as fluctuating water level also play major role in the colour of the soil (Majlis, 1967).

Farmers generally believe that dark colour is synonymous to fertile loamy soil. They tend to attribute fertility with colour without ascertaining the physical and chemical properties of the soil. Colour reflects an integration of chemical, biological and physical transformations and translocations that have occurred within a soil (Scheonberger et al., 2002).

The colour of the soil is usually determined by the nature of the fine material. Generally, the colour of the soil is determined by the quantity and state of the iron and/or the organic matter. Hematite (Fe_2O_3) for example is responsible for the red colour in many soils developed under strongly aerobic conditions in tropical and sub-tropical areas (Majlis, 1967). However, the mineral responsible for most of the inorganic colouration in aerobic soils is goethite (Fe O-OH), with colours ranging from reddish – brown to yellow as it's hydration increases.

Many grey, olive and blue colours occur in the soils of partially or completely anaerobic situations and originate from the presence of iron in the reduced or ferrous state. Sometimes, substances with blue colour such as vivianite may form under these conditions and therefore contribute to the colouration (Ojo-Atere et al., 2009).

The colour of the upper horizons usually changes from brown to dark brown to black, as the organic matter content increases, and there is a tendency for the organic matter to become darker in

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colour with increased humification (Ojo-Atere et al., 2009; Noma et al., 2010).

Horizons low in calcium and organic matter are often pale in colour, whereas in the presence of large quantities of calcium or sodium, dark colours will form even with small quantities of organic matter. Dark colours are produced also through the presence of manganese dioxide, or by the presence of elemental carbon following burning, Pale grey and white colours originate through the lack of alteration of grey or white parent materials, deposition of calcium carbonate, and efflorescences of salts (Ojo-Atere et al., 2009).

However, in view of other influences affecting the colour of the soil besides organic matter there is therefore the need to investigate the soil colour as pedo-transfer functions of soil chemical constituents including organic carbon with the aim of guiding the land users in the appropriate usage of land and its fertility maintenance.

II. Materials and Methods

a) Description of the Study Area

The research was conducted at Olabisi Onabanjo University Main Campus, Ago-Iwoye. The area lies on latitudes 6°55′ and 7°00′N and longitudes 3°45′ and 4°05′E. The area has a bimodal rainfall, with peaks between June – July and September – October. It has an annual rainfall of about 1150mm and it is located in the rainforest belt. Mean relative humidity of the area is generally high (about 80%) with the peak between May and October. The annual mean temperature is 27°C. Sunshine hour also follows the same trend as that of the temperature with the highest number of hours during dry season and the lowest during the wet season.

The natural vegetation of the area consists mainly of secondary forest except where human interference through annual uncontrolled bush burning and small scale farming methods have reduced the original forest to secondary ones, bush re-growth and thickets. The original forest is now mostly confined to river channels and swamps.

The site is generally undulating with a few gentle to steep slopes. Most of the soils in the survey area developed from undifferentiated igneous and metamorphic, pre-Cambrian basement complex rocks such as granite, biotite gneiss, biotite schist, quartz schist and quartzite. The rocks are fairly deeply weathered and the occurrence of rock out-crops in the survey area is not widespread. A major part of the site is generally well drained through the existing river channels.

The soil investigation of the site shows that most of the soils derived from coarse grained rocks are generally characterized by their varying amounts of quartz and/or ironstone gravel with some occasional stones in the top one meter of the profile. Varying quantities of gravel and stones may be found in the surface of these soils.

b) Field Work

Three land use types namely: Arable cropping (land use 1), Oil palm (land use 2) and secondary forest (land use 3) were studied.

At each of the chosen land use type, profile pits were dug at the three predominant different land type or slope segment encountered. These were crest, middle slope, and valley-bottom.

The general site description such as climate, vegetation, land use, gradient of slope, drainage type, soil surface form, type and degree of erosion, field texture, micro-relief and depths to ground water table were recorded. The pits were described, sampled and the samples analysed following standard procedures. A total of 9 profile pits were dug (3 at each land use) and 30 profile samples were collected for laboratory analysis.

c) Laboratory Analysis

The soil samples were air-dried and sieved with a 2mm - mesh sieve. Some portion of the sieved samples was further passed through 0.5mm - mesh sieve for organic matter and total N determination.

Soil samples were analysed for the following parameters: Soil pH was determined in both water and 0.01M potassium chloride solution (1:1) using glass electrode pH meter (Mclean, 1965). Total nitrogen was determined by the macro-kjeldahl digestion method of Jackson (1962), available P was extracted using Bray-1 extract followed by molybdenum blue colorimetry. Exchangeable cations were extracted with 1M NH_4OAC (pH 7.0), potassium, calcium and sodium were determined using flame photometer and exchangeable Mg by atomic absorption spectrophotometer (Sparks, 1996). Exchangeable acidity was determined by the KCl extraction method (Mclean, 1965), organic carbon was determined using dichromate wet oxidation method (Walkley and Black, 1934). Organic matter was got by multiplying the percent organic carbon by 1.72. Cation exchange capacity (CEC) was calculated from the sum of all exchangeable cations. Available micronutrients were determined by Atomic Absorption Spectro-photometer (AAS) method after leaching on NH_4Cl (Water and Sammer, 1948). Saturated hydraulic conductivity was determined using a constant head method, bulk density by core method, soil porosity was estimated from the bulk density data at an assumed particle density of 2650kgm-3. Water retention at 15 bar was determined in order to calculate available water holding capacities of the soil profile horizons (Mbagwu, 1985). Particle size analysis was by the Bouyoucos hydrometer (1951) method using calgon as dispersing agent.

d) Soil Colour Determination

The soil colour (moist and dry) were determined by the use of the Munsell colour chart in which a soil is held next to the chips to find a visual match and assigned the corresponding Munsell notation.

III. Results and Discussion

a) Morphological Properties

i. *Soil Colour*

The soils of the land use types were characterized by brown (5YR 5/4 – 10YR 6/4), sandyloam / loamysand, topsoil over reddish brown (2.5YR 4/8 – 7.5YR 6/8) sandy clayloam to sandy clay subsoil. The hue was generally 10YR for lowland arable soils, and 5YR to 7.5YR for the middle slope, while it ranges from 2.5YR to 7.5YR for the upland section. The reverse was the trend for land use 2, with lowland portion having a hue of 5YR, while the middle portion ranges from 7.5YR to 10YR.

However, in the secondary forest land use type, both the middle and summit sections were characterized with 7.5YR hue, while the toes slope / valley bottom section ranges between 2.5YR to 7.5YR hue (Table 1).

In addition, some sections of the valley bottom of both the arable and oil palm land use types exhibited some level of mottling as evidence of water saturation at some period of the year.

The colour difference showed that pedons on the crest and middle slopes were more reddish to brownish but greyish at the valley bottom. This variation in soil colour was due to the obvious sequences of drainage. This is in agreement with Noma et al., (2010). Besides, the influence of drainage on soil colour variation, it has been reported by Majlis (1967) that soil colour has been expressed too as a function of iron and organic matter contents, pH and type of clay mineral in the soil.

The fluctuating water table in the lower slope and valley bottom soils also resulted in the occurrence of hydromorphic mottles in these areas. The colours of the studied soils vary with depth. This is in conformity with Brady and Well (1999), who reported that soil colour typically changes with depth through the various horizons in a soil profile.

ii. *Physical Properties of the Soils*

The main physical properties of the soils are presented in tables 2 – 4. The land use 2 were generally more sandy than other land use types (i.e. land use 2 > land use 3 > land use 1). This decreases with depth, except in some cases, particularly at the sub-soil horizon (>50 in depth), where high percentage of sands were concentrated.

The high percentage of soil texture (41.8 – 91.2%) in all the land use types which is sandy is a good indication of the observable high infiltration rate and low water holding capacity of the soils, thereby resulting into moisture stress as reported by Senjobi, 2007. In addition, this scenario enhance rapid leaching of soil nutrients beyond roots exploration of the planted crops thereby threatens increase in food productivity and security.

The clay content increases down the profile. It ranges from 4.8 – 38% in both the surface and sub-surface soils. The differences in clay contents account for varied drainage pattern in the study site. Thus, while the valley bottom soils are poorly drained, the middle slope and crest are well drained across the land use types. The higher clay content at the valley bottom soils reduces infiltration rate of water as confirmed by Ahn, 1970 and Senjobi, 2007.

The water holding capacity of the soils increases with increase in clay content of the soils. The silt content in the soil is generally low and there is no definite sequence in its distribution within the profile. The silt: clay ratios are generally low.

The gravel content was very high ranging from 6.0 to 89.9% in nearby all the pedons. The pedons are composed of concretions, ferruginous nodules, quartz gravel and stones which concentrate as stone lines or stone layers (Sharpe, 1938; and Nye, 1954).

The erosion exposes a sheet of gravel mantle, which is subsequently buried by the sedimentation of fine textured materials. Stonelines interfere considerably with manual soil tillage and thereby limits the aggregate size of farmland that a farmer can put under cultivation. According to Babalola and Lal (1976) and Stoop (1987), this type of physical feature is, permanent and difficult to change.

The porosity of the land use soils is directly proportional to percent sand and gravel concentration, whereas the permeability is inversely proportional to the clay content. The bulk density and hydraulic conductivity are generally low with no definite sequence in their distribution within the profile.

iii. *Chemical Properties of the Soils*

The data on the chemical properties of the soils are given in Table 5 – 7. The pH values of the land use soils ranged between pH (H_2O (6.35 and 7.5) and KCl (5.10 and 6.46) in the surface layer. These values had no definite sequence in their distribution down the profiles.

The organic carbon fluctuates irregularly with depth for most of the pedons and this is an indication of continuous deposition of organic material. The value of organic carbon ranged from 0.27% to 1.66% in the surface layers, with the highest concentration on the surface soils in most pedons. The low organic carbon values in some pedons may be partly due to the high temperature and high relative humidity, which favour rapid mineralization. Organic matter has been reported

to have positive influence on the CEC, base saturation, structure, pH, buffering capacity, soil colour and water holding capacity (Majlis, 1967 and Ahn, 1970). The organic matter content of the surface horizons in all the land use types is appreciable. This may be due to the fact that most of the organic residues in both cultivated and virgin soils are incorporated or deposited on the surface. The organic matter content of soils under secondary forest and oil palm cultivation are higher than those of arable cultivation. This may be because the soils under those land use systems are always covered and they have not been subjected to intense cultivation as in arable land use type.

The incorporation of organic residues into the soils through tillage practices at the arable land use type has contributed to the relatively higher level of organic matter in this site.

The total nitrogen content in all the soils of land use types is generally low (0.01 – 0.19%) compared with the critical value of 0.15% (Agboola and Corey, 1973). The intense cultivation of the soils normally increases the rate of mineralization of the organic matter, thus negatively affect the level of total N content in the soil. The available P is generally moderate in most of the pedons and high in the remaining pedons compared with the critical level of 10 – 16 ppm (Adeoye and Agboola, 1985).

The exchangeable cations Ca, Mg, K and Na are generally low in all the pedons. This may be attributed to intense cultivation, leaching of nutrients and weathering. Hence, the inherent low fertility status of the soils.

iv. *The relationship between soil colour and some selected soil chemical properties*

In land use 1, the exchangeable bases increases across the crest and middle slope land types as the hue 10YR – 25YR decreases in the surface soils except for Mg. However, at the valley bottom soils, the reverse is the trend.

Organic carbon on the other hand increases with decrease in the hue of the soils irrespective of the land type in land use 1. The same trend was observed for exchangeable acidity. However, phosphorous value decreases as the hue decreases in all the land types, while Zn is constant.

At land use 2, the exchangeable bases except for calcium follow The, reverse trend as compared to the trend in land use 1. While organic carbon increases in land use 1, the reverse is the trend in the land use 2, with nitrogen following the same sequence as organic carbon.

Exchangeable acidity, phosphorous and Zinc only decreases with decreasing soil hue in valley bottom soils, and increases in the other land types.

At land use 3, only sodium and potassium increase with decreasing hue (7.5YR – 25YR) at the crest and middle slope sections, while at valley bottom soils the reverse is the trend.

While magnesium increases with decreasing soil hue across the land types, organic carbon, calcium, zinc and copper decreases with decreasing soil hue. Nitrogen, phosphorous and pH KCl as well as exchangeable acidity follow the same sequence with sodium and potassium in land use 3.

IV. Conclusion

It was evident from the study that the colour of soils is not a sufficient parameter in determining the organic carbon accumulation and fertility status of the soil. Furthermore, the complex relationship between soil colour and some selected chemical properties of the soil revealed that land use analysis or soil testing programme remains the vital tool in assessing fertility status of the soil for optimal and sustainable production. This in turn will guide in the area of fertilizer recommendation and soil nutrient management.

The occurrence of heavy metals in the soil beyond their critical levels is in no doubt contributing to the colour of the soil. This may misguide the absolute reliance on soil colour as pedo-transfer functions for soil fertility status especially in this age of global pollution as the case were in the past when there was little or no pollution history.

Further studies are needed using a wide range of soil colour before ascertaining possible relationship between soils of this area and those elsewhere and in addition, the chemical parameters.

Furthermore, organic agriculture and precision farming will however go a long way to improve and sustain the fertility status of the soil for optimal and sustainable production. Thus, a good organic matter management involving residues incorporation through the addition of large quantities of farm yard manure and the practice of green manuring that could impact dark colour to soil should be encouraged.

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Table 4.1 : Morphological Properties of the Pedons and Soils under the Different Land Uses

Profile No.	Parent Material	Land Use	Horizon Designation	Depth (cm)	Colour		Boundary	Textural Class	Structure	Consistency	Quartz	Concretions	Roots	Drainage	Mottles
					Moist	Dry									
					Slope (10%)										
P_1 (VB)	Basement Complex	Fallow/Cassava	Ap	0-46	10YR 6/4	10YR 5/6	cl	SCL	Sg – sbk	ss, sp, vfr, Io	-	c	vf, f	pd	-
			Bc	46-76	10YR 5/6	–	gs	SCL	P	ns, np, Io	f	vm	vf, vf	pd	5YR 5/4
			Bt	76-126	10YR 5/6	–	cl	SCL	Co	s, p, h	f	f	vf, vf	pd	5YR 4/2
					Slope (5%										
P_2 (MS)	”	Cassava/Plantain	Apc	0-18	7.5YR 3/2	–	ab, s	SC	G	ns, np, Io	f	vm	vf, f	wd	-
			Btc	18-57	5YR 5/4	–	cl, w	SC	Ab	s, p, fr	-	vm	vf, vf	wd	-
			Bt	57-118	5YR 5/6	–	ir	SCL	Sg	st, sp, fr	-	c	vf, vf	wd	-
					Slope (1%)										
P_3 (C)	”	Cassava/Maize	Apc	0-14	5YR 6/8	–	di, s	SCL	Ab	s, sp, f	f	vm	vf, vf	wd	-
			Bt	14-23	5YR 5/8	–	di, s	SCL	Ab	s, sp, f	f	vm	vf, vf	wd	-
			Btc	23-53	7.5YR 6/6	–	ab, s	SCL	G	vs, p, f	-	vm	vf, vf	wd	-
			Bt	53-112	2.5YR 4/8	–	cl	CL	M	vs, vp, vh	-	f	vf, vf	wd	-
					Slope (6%)										
P_4 (VB)	”	Oil Palm	Ap	0-30	5YR 4/3		ab, s	SL	Sg	ns, ns, Io, vf	-	vm	c – m	wd	-
			Btc	30-110	5YR 6/6	5YR5/8	s	SCL	g/m	s, p, fr	-	vm	vf, vf		
					Slope (3%)										
P_5 (MS)	Basement Complex	Oil Palm	Ap	0-34	5YR 2/2	5YR4/2	ab, s	S	Sg	ns, np, vfr		f	m, me-co	wd	-
			AB	34-69	5YR 4/4	5YR6/3	cl, ir	LS	sg	ns, np	-	c	c, me	wd	-
			B	69-113	7.5YR 5/6	7.5YR5/8	g, ir	LS	g	ns, np	-	vm	f,m-c0	wd	-
			BC	113-137	7.5YR 5/6	10YR6/6	di	LS	g-cr	ns, np	f	vm	vf,vf	wd	5YR 3/2
					Slope (0.5%)										
P_6 (C)	”	Oil Palm	Ap	0-33	7.5YR 3/2	7.5YR4/4	cl, s	S	sbk –gb	ns, np	f	c	m, f-co	wd	-
			BC	33-65	7.5YR 5/6	7.5YR6/4	cl, w	SC	ab	ns, np, Io	f	vm	f, f–me	wd	-
			Bt	65-112	10YR 5/8	7.5YR5/8	di, s	SC	m	vs, p, fr	-	vm	vf, vf	wd	-

Profile No.	Parent Material	Land Use	Horizon Designation	Depth (cm)	Colour		Boundary	Textural Class	Structure	Consistency	Quartz	Concretions	Roots	Drainage	Mottles
					Moist	Dry									
							Slope (2%)								
P_8 (MS)	Basement Complex	Fallow	Apc	0-19	5YR 5/6	–	ab, w	LS	g	ss, lo	f	vm	f, vf	wd	-
			Bc	19-43	5YR 6/4	–	cl, s	SL	g	ss, fr	f	vm	vf, vf	wd	-
			Bt_1	43-64	7.5YR 6/8	–	g w	LS	m	s, f	-	vm	-	wd	-
			Bt_2	64-108	7.5YR 5/6		W	SL	m	vs, p, vf	-	vm	-	wd	-
							Slope (4%)								
P_9 (C)	”	Fallow	Apc	0-41	5YR 5/4	–	cl, s	S	g	ns, io	f	vm	m,f-co	wd	
			Bc	41-64	5YR 5/6	–	ab, s	SL	sbk	ns, io, vf	-	vm	m,f-me	wd	
			Btc_1	64-147	7.5YR 6/8	–	g, di	SL	sbk	ns, io	-	vm	m,f-me	wd	
			Btc_2	147-167	10YR 7/6	–	Di	SCL	m	ss, fr	-	vm	vf, vf	wd	
							Slope (4%)								
P_{10} (VB)	”	Secondary Forest	Apc	0-31	7.5YR 5/8	-	ab, s	SL	g	vs, fr	f	f	f, vf	wd	
			Btc	31-108	2.5YR 4/8	–	di, ir	SL	sg	Vs	-	f	vf, vf	wd	
							Slope (2%)								
P_{11} (MS)	”	Secondary Forest	Ap	0-30	7.5YR 5/8	-	ab, s	LS	sg	ns, lo	-	f	f, f-me	wd	-
			B	30-62	7.5YR 5/6	-	g, w	LS	sg	ns, lo	-	f	vf, vf	wd	-
			Btc	62-112	7.5YR 7/8	-	di	SL	g	vs, vf	f	vm	c,me-co	wd	-
							Slope (1%)								
P_{12} (C)	Basement Complex	Secondary Forest	Ap	0-50	7.5YR 6/8	–	cl, w	LS	sbk	vs, f	f	f	f, vf	wd	-
			Bt	50-86	7.5YR 5/8	–	di,	SCL	m	vs, vp, vf	-	f	vf, vf	wd	-
			Btc	86-128	7.5YR 5/6	–	g, w	LS	sg	ns, lo	-	vm	vf, vf	wd	-

+ Boundary: ab = abrupt, cl = clear, g = gradual, di = diffuse, s = smooth, w = wavy, ir = irregular.

[1] Textural class: LS = loamy sand, s = sand, SL = Sandy loam, SC = Sandy clay, SCL = Sandy clay loam.

[2] Structure: sbk = Subangular blocky, ab = angular blocky, sg = single grain, m = massive, co = coarse, p = prismatic, cr = crumb, g = granular.

[3] Consistency: ns = non-sticky, np = non-pastic, lo = loose, s = sticky, p – plastic, f = firm, h = hard VS = very sticky, vp – very plastic, vh = very hard, fr = friable, vfr = very friable, sp = slightly plastic, ss = slightly sticky.

[4] Quartz: f = few, - = Absent

[5] Concretions: f = few, c = common, m = many, vm = very many.

[6] Roots: vf = very few, f = few, c = common, m = many (concentration) vf = very fine, f = fine, me = medium, co = coarse (size).

[7] Drainage: wd = well drained, pd = poorly drained.

[8] VB=Valley-Bottom, MS=Middle Slow and C=Crest

Table 2 : Physical Properties of the Soil under Cassava

Profile No.	Horizon Designation	Depth (cm)	Gravel	Sand (g/kg)	Silt	Clay	Silt: Clay Ratio	Porosity (%)	Textural Class	WHC (%)	BD (g/cm^3)	HC (cm/hr)	Permeability
P_1 (VB)	Ap	0-46	226	508	202	290	0.70	50.6	SCL	24.1	1.31	1.68	13.6
	Bc	46-76	775	642	148	210	0.70	47.4	SCL	28.3	1.40	1.53	12.5
	Bt	76-126	102	522	118	360	0.33	44.2	SC	28.5	1.41	1.55	12.2
P_2 (MS)	Apc	0-18	687	472	158	370	0.43	51.9	SC	34.8	1.28	2.82	23.8
	Btc	18-57	663	508	142	350	0.41	55.8	SC	31.6	1.17	0.54	3.24
	Bt	57-118	201	468	202	330	0.61	43.4	SCL	35.0	1.50	1.08	4.43
P_3 (C)	Apc	0-14	808	492	220	288	0.76	41.7	SCL	33.3	1.55	1.32	12.1
	Bt	14-23	593	672	120	208	0.58	45.9	SCL	38.9	1.44	0.99	7.4
	Btc	23-53	487	532	188	280	0.67	43.5	SCL	38.8	1.43	0.10	6.8
	Bt	53-112	135	418	202	380	0.53	42.6	CL	47.5	1.42	0.10	6.7

p = ploughed, c = concretion, t = illuvial accumulation of clay

LS = loamy sand, s = sand, SL = sandy loam, SC = sandy clay, SCL = Sandy Clay loam

VB=Valley-Bottom, MS=Middle Slow and C=Crest

WHC = water holding capacity (%), BD = bulk density (g/cm^3), HC = hydraulic conductivity (cm/hr)

Table 3 : Physical Properties of the Soil under Oil Palm

Profile No.	Horizon Designation	Depth (cm)	Gravel	Sand (g/kg)	Silt	Clay	Silt:Clay Ratio	Porosity (%)	Textural Class	WHC (%)	BD (g/cm^3)	HC (cm/hr)	Permeability
P_4 (VB)	Ap	0-30	893	612	320	68	4.71	53.2	SL	43.8	1.24	0.57	5.01
	Btc	30-110	705	558	142	300	0.47	49.9	SCL	55.4	1.07	0.40	3.12
P_5 (MS)	Ap	0-34	174	912	40	48	0.83	30.6	S	18.6	1.84	0.84	6.12
	AB	34-69	253	872	80	48	1.67	37.4	LS	23.5	1.66	0.75	5.16
	B	69-113	631	872	40	88	0.45	41.0	LS	29.8	1.57	0.78	5.43
	Bc	113-137	612	812	140	48	2.92	42.8	LS	23.5	1.52	0.48	2.85
P_6 (C)	Ap	0-33	251	912	40	48	0.83	42.5	S	28.7	1.53	0.54	3.39
	Bc	33-65	627	508	142	350	0.41	35.1	SC	25.7	1.72	1.13	9.90
	Bt	65-112	899	532	120	348	0.34	53.4	SC	38.7	1.24	0.85	7.90

Table 4 : Physical Properties of the Soil under Secondary Forest

Profile No.	Horizon Designation	Depth (cm)	Gravel	Sand (g/kg)	Silt	Clay	Silt: Clay Ratio	Porosity (%)	Textural Class	WHC (%)	BD (g/cm^3)	HC (cm/hr)	Permeability
P_{10} (VB)	Apc	0-31	133	712	160	128	1.25	42.5	SL	23.8	1.53	1.05	7.89
	Btc	31-108	99	752	120	128	0.94	43.8	SL	23.1	1.49	2.22	18.48
P_{11} (MS)	Ap	0-30	60	812	140	48	2.92	54.2	LS	35.5	1.22	1.74	14.01
	B	30-62	157	812	120	68	1.76	38.9	LS	26.1	1.62	2.40	20.13
	Btc	62-112	444	672	140	188	0.74	31.2	SL	21.9	1.83	1.11	8.43

P_{12} (C)	Ap	0-50	143	872	80	48	1.67	44.0	LS	53.2	1.49	0.69	1.77
	Bt	50-86	95	672	120	208	0.58	40.5	SCL	43.2	1.57	0.57	3.81
	Btc	86-128	495	872	80	48	1.67	45.5	LS	34.0	1.45	0.30	1.38

Table 5 : Chemical Properties of Soils under Cassava/Maize/Plantain/Banana

Profile No.	Horizon Designation	Depth (cm)	pH H_2O	pH KCl	Exchange Bases cmol.kg^{-1}				Ex AC	ECEC (soil)	B. Sat %	% C	Total N (%)	P	Zn mg.kg^{-1}	Cu
					Na	K	Ca	Mg								
P_1 (VB)	Ap	0-46	7.20	5.10	0.34	0.21	1.04	2.06	0.05	3.70	98.65	0.32	0.02	4.71	5.70	5.60
	Bc	46-76	7.15	4.75	0.48	0.30	1.18	1.60	0.05	3.64	98.63	0.38	0.04	1.88	5.40	5.30
	Bt	76-126	7.05	5.65	0.29	0.19	0.86	1.73	0.05	3.12	98.40	0.29	0.02	5.18	6.90	5.10
P_2 (MS)	Apc	0-18	7.00	6.15	0.39	0.43	1.15	1.73	0.06	3.76	98.40	1.54	0.13	2.82	6.20	5.60
	Btc	18-57	7.25	6.10	0.30	0.36	0.78	1.87	0.05	3.36	98.51	0.29	0.03	13.65	5.80	3.70
	Bt	57-118	6.05	5.10	0.25	0.24	1.14	1.21	0.11	2.95	96.27	1.22	0.13	10.35	4.60	5.20
P_3 (C)	Apc	0-14	6.35	5.20	0.36	0.41	1.10	2.00	0.09	3.96	97.73	1.66	0.16	1.88	5.00	5.60
	Bt	14-23	5.95	5.20	0.27	0.21	1.16	1.19	0.11	2.94	96.26	0.40	0.03	10.35	7.00	6.10
	Btc	23-53	6.15	5.05	0.24	0.15	1.23	1.50	0.10	3.22	96.89	1.10	0.10	6.12	6.10	5.60
	Bt	53-112	6.05	4.95	0.23	0.14	1.18	1.65	0.11	3.31	96.68	1.13	0.11	7.06	6.40	4.80

P = ploughed, c = concretion, t = illuvial accumulation of clay

VB=Valley-Bottom, MS=Middle Slope and C=Crest

Table 6 : Chemical Properties of Soils under Oil Palm

Profile No.	Horizon Designation	Depth (cm)	pH H_2O	pH KCl	Exchange Bases cmol.kg^{-1}				Ex AC	ECEC (soil)	B. Sat %	% C	Total N (%)	P	Zn mg.kg^{-1}	Cu
					Na	K	Ca	Mg								
P_4 (VB)	Ap	0-30	7.10	6.15	0.25	0.21	1.05	1.56	0.05	3.12	98.40	1.57	0.16	11.76	5.30	5.90
	Btc	30-110	6.65	5.05	0.47	0.29	1.15	1.83	0.08	3.82	97.91	0.43	0.05	3.29	5.00	5.20
P_5 (MS)	Ap	0-34	6.70	5.65	0.20	0.12	1.14	1.38	0.08	2.92	97.26	1.01	0.10	14.12	6.20	5.70
	AB	34-69	6.60	5.75	0.21	0.10	1.25	1.44	0.08	3.08	97.40	1.31	0.13	7.06	5.80	6.50
	B	69-113	6.70	5.90	0.28	0.14	0.90	1.71	0.08	3.11	97.43	0.16	0.01	10.35	4.80	3.90
	Bc	113-137	6.95	5.90	0.24	0.14	0.89	1.89	0.06	3.22	98.14	0.38	0.04	10.00	4.90	4.50
P_6 (C)	Ap	0-33	7.50	6.20	0.31	0.30	1.04	1.75	0.04	3.44	98.84	0.99	0.10	5.18	6.00	4.90
	Bc	33-65	6.90	6.00	0.26	0.13	0.96	1.79	0.06	3.20	98.13	0.48	0.05	8.47	6.20	4.70
	Bt	65-112	6.80	5.90	0.26	0.15	0.99	1.19	0.07	2.66	97.37	0.50	0.06	6.59	6.00	6.50

Table 7 : Chemical Properties of Soils under Secondary Forest

Profile No.	Horizon Designation	Depth (cm)	pH H_20	pH KCl	Exchange Bases cmol.kg^{-1}				Ex AC	ECEC (soil)	B. Sat %	% C	Total N (%)	P	Zn mg.kg^{-1}	Cu
					Na	K	Ca	Mg								
P10 (VB)	Apc	0-31	6.70	5.45	0.28	0.18	1.08	1.48	0.08	3.10	97.42	1.33	0.13	8.94	6.20	5.60
	Btc	31-108	6.40	5.65	0.23	0.13	1.03	1.38	0.09	2.86	96.85	0.67	0.07	5.18	6.00	5.40
P11 (MS)	Ap	0-30	6.90	6.45	0.32	0.50	1.08	1.93	0.06	3.89	98.46	0.27	0.03	3.76	5.70	5.30
	B	30-62	6.80	5.80	0.23	0.15	1.06	1.98	0.07	3.49	97.99	0.32	0.03	1.14	4.80	4.70
	Btc	62-112	6.65	5.75	0.33	0.28	0.90	1.87	0.08	3.46	97.69	0.21	0.02	0.94	4.80	4.50
P12 (C)	Ap	0-50	6.80	5.60	0.28	0.24	1.01	1.93	0.07	3.40	97.50	0.54	0.05	8.47	5.10	4.10
	Bt	50-86	6.75	5.80	0.26	0.29	0.91	1.93	0.08	3.47	97.69	0.66	0.06	13.17	5.30	4.40
	Btc	86-128	6.30	5.30	0.36	0.21	0.99	1.73	0.09	3.38	97.34	0.61	0.06	1.14	5.40	4.40

Global Journal of Science Frontier Research
Environment & Earth Science
Volume 13 Issue 1 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Water Consumption Minimizing in Hydrophilic Cotton Manufacturing and Sterile Gauze Industries

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Abstract - Among all industries hydrophilic cotton from raw cotton and all type of medical gauze from textile productions have high water consumption. Due to this reason water recycles and reuse in these industries and generally water usage minimization in these units have especial importance. For practical research in this context one of domestic industry has been selected as a case study. Water usage minimization in other industries have been investigated in different countries, but nearly all these researches are related to minimization of water consumption in raw cotton production. Results showed that minimization of water consumption whit recycle and reuse method in these industries are very successful, to the extent of water can be saved about 65 percent after and simple aeration and reservation for 10 hours and recycling in to production recycle. Usually in these industries three types of consumption exist: one for hydrophilic cotton production, next for medical gauze and last for general consumption. In selected industry for medical gauze production and hydrophilic cotton, the amounts of water consumption are 40 lit/kg and 43 lit/kg respectively. And the remaining is about 20 lit/kg for other consumption, such as boiler, chiller, restaurant, personal and … consumption. Regarding water quality needed for every stage of production.

Keywords : *cotton beating, stamping, wastewater recycle, reuse, hydrophilic cotton.*

GJSFR-H Classification : *FOR Code: 820301*

Strictly as per the compliance and regulations of :

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Seyed Mostafa Khezri [α] & Bahareh Ghafari [σ]

Abstract - Among all industries hydrophilic cotton from raw cotton and all type of medical gauze from textile productions have high water consumption. Due to this reason water recycles and reuse in these industries and generally water usage minimization in these units have especial importance. For practical research in this context one of domestic industry has been selected as a case study. Water usage minimization in other industries have been investigated in different countries, but nearly all these researches are related to minimization of water consumption in raw cotton production. Results showed that minimization of water consumption whit recycle and reuse method in these industries are very successful, to the extent of water can be saved about 65 percent after and simple aeration and reservation for 10 hours and recycling in to production recycle. Usually in these industries three types of consumption exist: one for hydrophilic cotton production, next for medical gauze and last for general consumption. In selected industry for medical gauze production and hydrophilic cotton, the amounts of water consumption are 40 lit/kg and 43 lit/kg respectively. And the remaining is about 20 lit/kg for other consumption, such as boiler, chiller, restaurant, personal and … consumption. Regarding water quality needed for every stage of production. The wastewater of some units can be used as fresh water for other units, by this method the total consumption of this factory can be reduced to $\frac{1}{3}$ of total of it, without damaging quality of factory production.

Keywords : cotton beating, stamping, wastewater recycle, reuse, hydrophilic cotton.

I. Introduction

Cotton processing and health cotton production uses large amounts of water and from the various stages of this processing are produced large volumes of wastewater in the end of process, which requires proper treatment before entering the environment. Increasing public concerns about environmental issues and surface and underground water sources and raw water scarcity has led to the closure of some industries [5] [10].

Today, due to shortage of raw water tend to the new sewage treatment methods of these units and reuse of them has increased and also attempts has been made to substitute water with other chemicals to wash the cotton.

Consumers and manufacturers in order to protect and safeguard the environment and natural resources tend to use natural approaches to sewage treatment and water recovery for urban water use efficiency.

Considering that the hydrophilic and sterile cotton processing wastewater contains high concentrations of COD, BOD and color, efforts to minimize quantity and quality of produced wastewater and finding a suitable treatment method for water recycling and using recycled water in production processes for these industries are very high in importance [4].

Old methods for processing cotton have a large amount of water consumption so the today main challenge is the search of new technologies and changes in production methods.

So that these methods have greater compatibility with the environment, economic issues have also a special priority.

These methods should also have high efficiency as well as less production of wastewater and the quality of output effluent and the recycled water can also compete with the old technology or is even better and all these operations take place with minimal costs [7].

Water consumption in these industries is very high, but yet a comprehensive study on water use minimization techniques has not been done in this area and also on how they can reduce consumption of raw water and how to use water has been retrieved.

Given the importance of these industries, and reduction of water supplies, this research has a great importance.

In the subject of this study has not been conducted no similar work in the inside and outside of the country, but one can point to studies which have addressed this issue in part as follows:

A research about how new and clean cotton clothing worn by the laser beam has been done in England in 2000 by Howard Suteliffe [1].

Also in the faculty of Chemical Engineering - University of Guilan, Rasht, a research on using nanotechnology as the photo catalytic which is used to

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clean cotton that has been conducted by Mr. Falah Moafi.

A research by Mr. Khezri and colleagues related to evaluation of the quality of wastewater treatment of cotton processing and offering optimized method was carried out in 1390 in Tehran [7].

And another investigation in relation to sewage treatment of hydrophilic cotton and evaluation and providing the optimal method by Mr. Khezri and colleagues has been conducted in 1390 in Tehran [10].

II. Materials and Methods

The aim of this study is to investigate the minimization of water use in the industry of hydrophilic cotton processing and production of sterile and hygienic gauze. To achieve this goal one of the domestic industries has been selected as a case study [3].

This plant can be selected as an indicator and sample of the total factories in domestic and even abroad regions. The work method is a field study which starts with the full identification of cotton and gauze production process. And then the water needs of each of the processing units and quality of these waters will be found. Finally the water consumed in each line having the characteristics of raw water in another process is consumed in that process and if these conditions are not satisfied collecting them in a pond and aeration and also giving the required time, it acquires the necessary conditions for some processes.

Thus, the research method is a field and analytical method. Certain material has not been used in this study, except chemical materials in experiments related to water which include TSS, COD and BOD. Required equipments include thermometers and digital pH meters [2] [3].

III. Results

Consuming water in plants of hydrophilic cotton and sterile gauze production can be divided into three parts:

1- consuming water in hydrophilic cotton
2- water used in the production of sterile gauze
3- consuming water in staff costs and other expenses

In accordance with the measurements total water consumption of different months is shown in Figure 1.

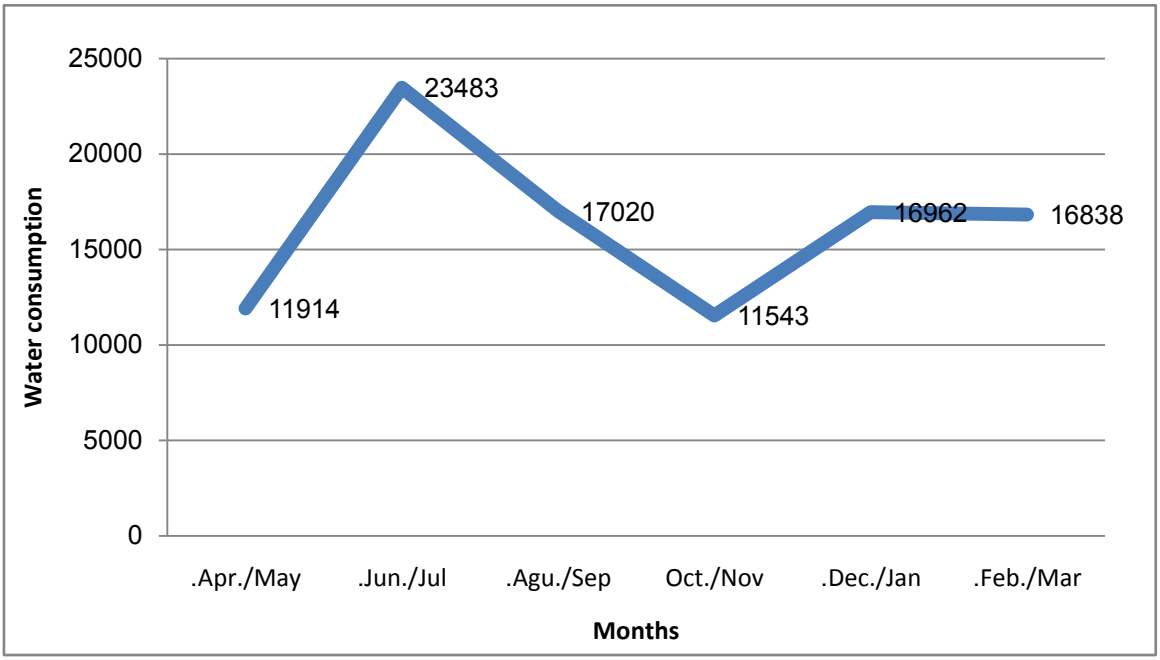

Figure 1 : Total water consumption of different months in term of (m^3/year)

Figure 2 is a breakdown of consumption

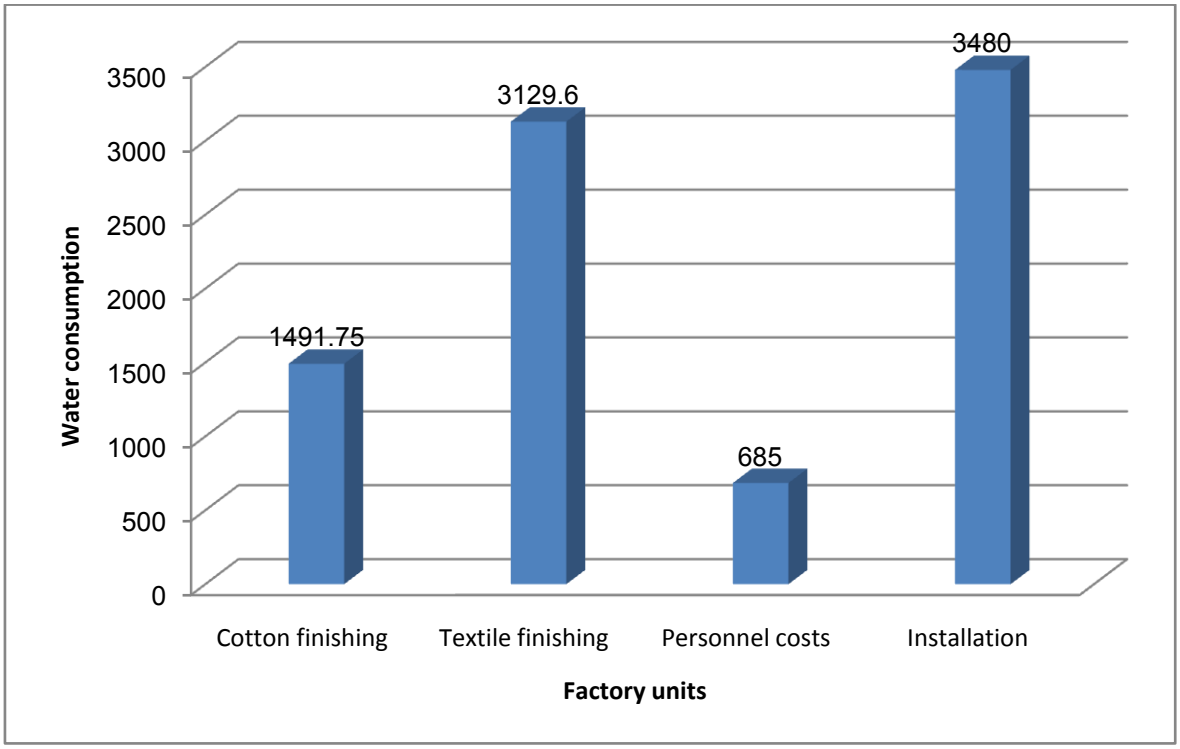

Figure 2 : Total amount of municipal water consumption in factory units in month in term of (m^3)

On average 43 liters of water per one kg of hydrophilic cotton and 40 liters of water per one kg of sterile gauze is consumed, but this amount is the raw water intake after following the minimization issues which will be explained in detailed.

The schematic diagram of hydrophilic cotton production is as diagram 3.

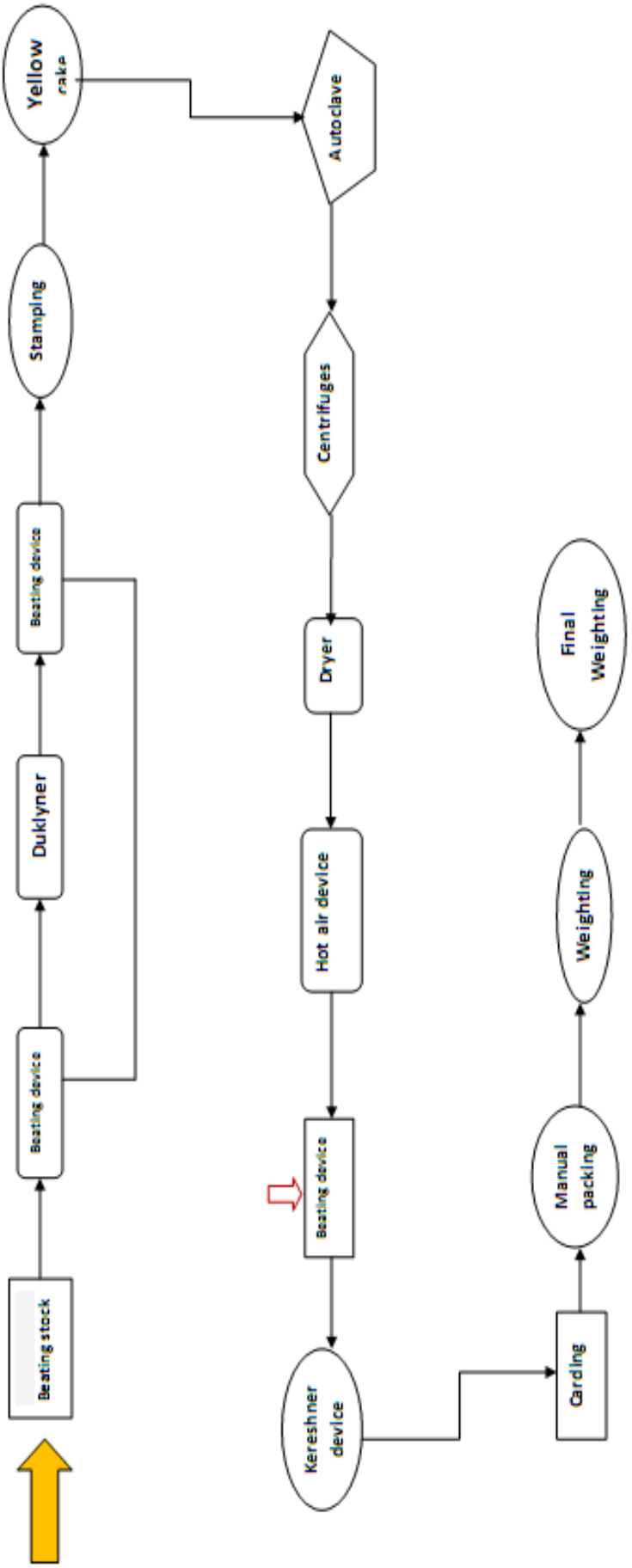

Figure 3 : Diagram of hydrophilic cotton production

Water consumption in the processing and operational units is mainly related to stamping and autoclave. The amount of water consumption in the stamping unit is 6 cubic meters per every 120 kg mould. Also the water consumption of this phase is the most of all steps and is almost three times the autoclave phase.

In Autoclave unit per 360 kg (three 120 kg mould) Cotton, 12 cubic meters of water is consumed. The completion process of sterile is shown in Figure 4.

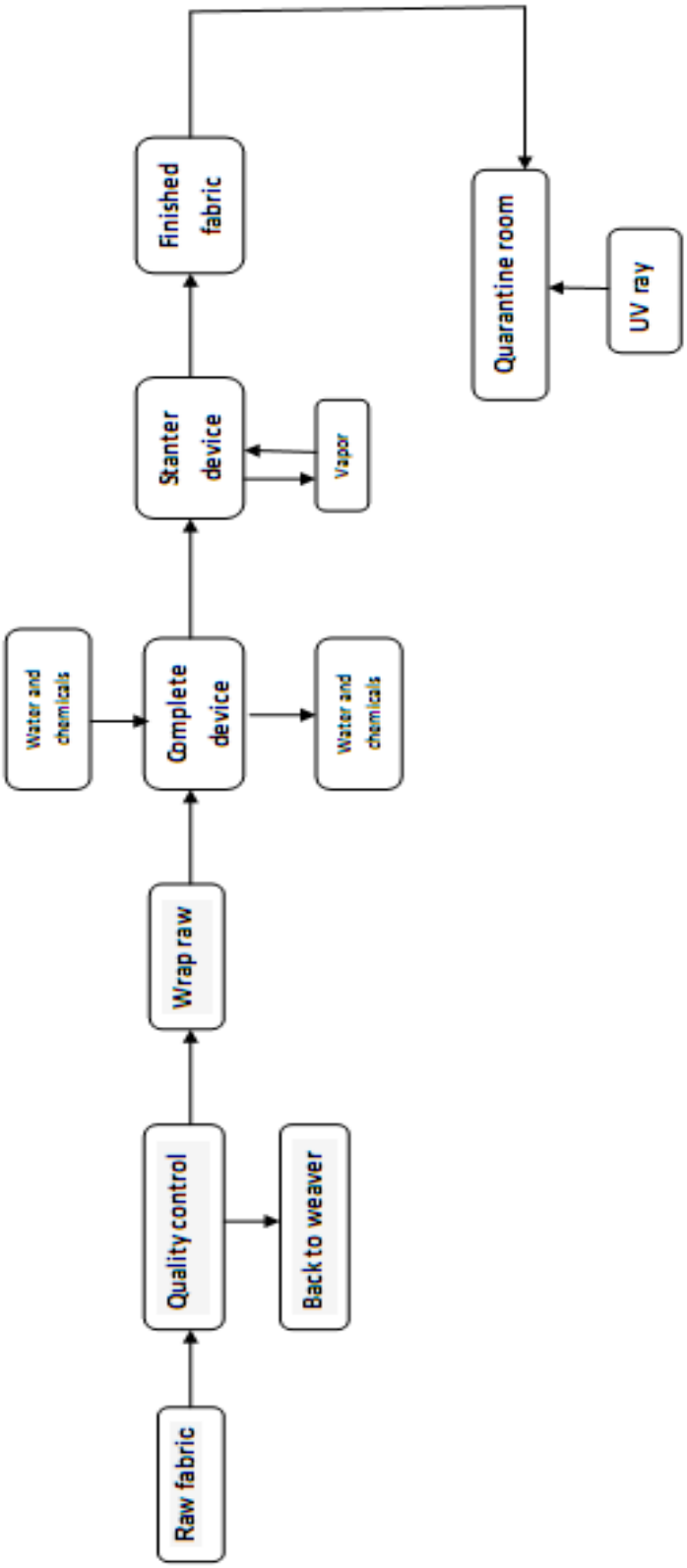

Figure 4 : Completion processof sterile gauze

Sterile consuming water is required for the completion of washing, whitener, reduce fat and eliminate microbial contamination that can be done in completing this work. In this stage a large amount of raw water is used for washing. Per kilogram of gas, 40 liters of raw water are consumed.

In the process of cotton production in some parts in consequence of the water and chemicals use, waste water is produced.

In Figure 5 is shown the different units of hydrophilic cotton processing in which wastewater is produced.

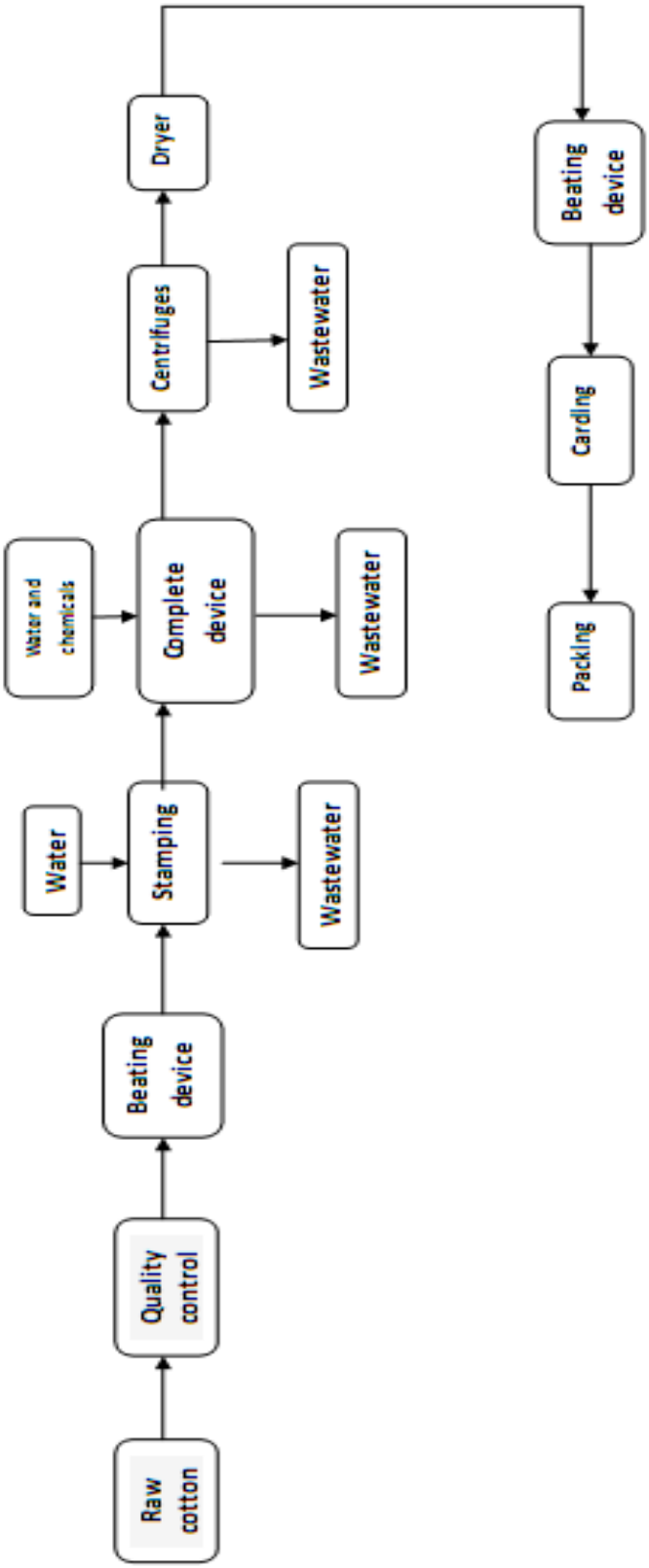

Figure 5 : Wastewater producing in hydropilic cotton process

In the stamping units per a 120 kg mould of the cotton, 6 cubic meters of wastewater is produced. During a working day, as a result of using this device is produced 48 cubic meters of sewage water.

Then, in an autoclave or completion system the water and chemicals are used for washing, bleaching and fat removing of the cotton. In this stage because of caustic soda, detergents, hydrogen peroxide and acetic acid there is a considerable amount of waste. The amount of waste produced in an autoclave for 3 hours at per 120 kg batch is equal to 12 cubic meters of sewage. The total amount of wastewater generated in this sector at 24 hours (a working day), the value is estimated at 96 cubic meters.

Finally, in the hydrophilic cotton processing process, some waste is produced in centrifuges. In Table 1, the amount of waste produced in the studied factory is shown in terms of cubic meters a day.

Table 1 : The amount of waste produced in the hydrophilic cotton processing

Name of units	Autoclave	Stamping	Centrifuges
The amount of waste produced(m^3/day)	80	48	16

Strategies for reducing urban water consumption in hydrophilic cotton and sterile processing units:

In the stamping unit due to its specific mechanisms, the hammers which act as a hammer blow cause to soak the cotton in the water and grind the two together. At last they convert into the mould of the so-called "yellow cake". The weight of this format is 120 kg.

As a result, water can be provided from the retrieved water from the processing and manufacturing stages.

In the Autoclaving or cooking pot, six main functions are accomplished:

1 - Cooking 2 - bleaching 3 - neutralization 4 - three-stage rinses

For saving and reduction and minimizing the consumption of raw water one can use recycled water in three parts of autoclave machine and raw water in three parts of rinse in the autoclave device.

Therefore for every 360 kg of the hydrophilic cotton is harvested, 6 cubic meters of recycled water and 6 cubic meters of raw water.

Due to differences in water quality requirements for processed cotton in various parts of it, required water of some of the units can be supplied by the recycled water and raw water can be provided for other units.

In Figure 6 is shown the percentage of water use in expressed process after minimization strategies and use of recycled water, and ultimately reduce the consumption of raw water.

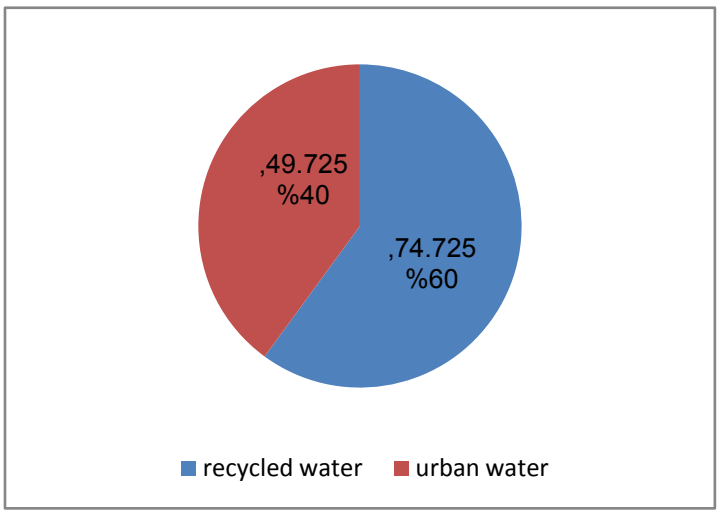

Figure 6 : The percentage of urban and recycled water use in cotton processing in term of (m^3/day)

60 percent of water used in the completion of hydrophilic cotton is provided by the recycled water and the remainder, 40%, is supplied by the raw water.

Minimization in the processing unit and the production of sterile and sanitary gauze is as follows:

To wash fabrics with chemicals, due to the lack of importance of water quality, recycled waters from the production and processing phases in different stages can be used and raw water can be useful for rinsing and dry-cleaning cloth is also applicable.

According to Figure 7 a significant savings have been achieved in the raw water intake in washing and completion of sterile and hygienic gauze.

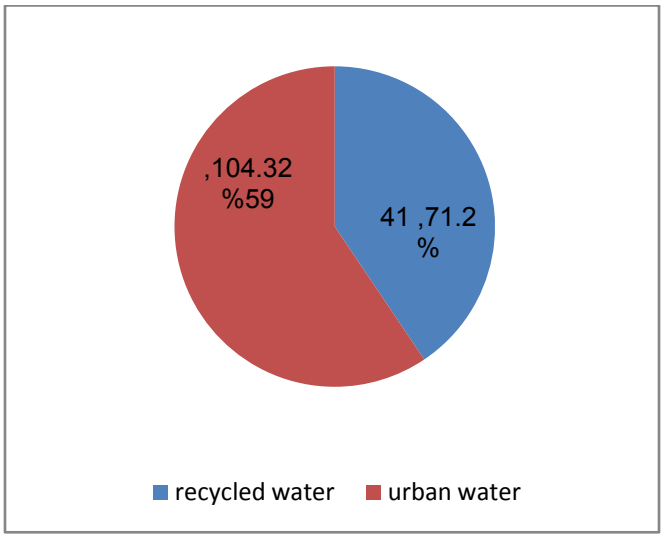

Figure 7 : The percentage of urban and recycled water use in completion processing in term of (m^3/day)

A large amount of raw water, 59%, is consumed to finish fabric which is considerable compared with respect to recycled consumption water with a rate of 41 percent.

But turning back the retrieved waters to the production line and completion of sterile gauze, significant savings at this stage and the amount of raw water have been achieved

By applying all of these mechanisms still some waste is generated that is necessary to think of a solution for its treatment. Currently these wastewaters enter the wastewater treatment site whish its treatment stages are shown in Figure 8.

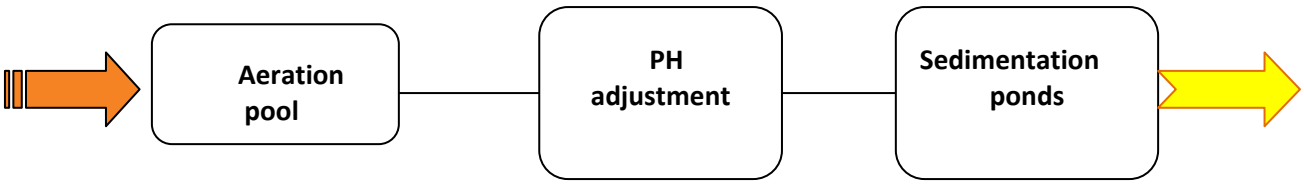

Figure 8 : Wastewater treatment site

Sampling of the input and output sectors of this treatment site that has been done in several cases, on average leads to the summarized results of Table 2 and 3.

Table 2 : Sampling of the input sector of this treatment site

Physical exam	Unit	Value
Temperature	C°	70
Chemical exam	**Unit**	**Value**
COD	(Mg/l)	2600
BOD_5	(Mg/l)	980
TSS	(Mg/l)	320
pH	_	12

Table 3 : Sampling of the output sector of this treatment site

Physical exam	Unit	Value
Temperature	C°	45
Chemical exam	**Unit**	**Value**
COD	(Mg/l)	2500
BOD_5	(Mg/l)	-
TSS	(Mg/l)	120
pH	_	0

As can be seen, the current treatment system is not exactly fulfilling EPA standards and cannot be disposed to be receptive sources.

IV. Conclusion

Looking at the cases of consumption in the processing units of hydrophilic cotton and production of sterile and sanitary gauze one can conclude that the most consumption is in the completion unit of fabric and the autoclave and stamping units [8] [11].

Fortunately stamping unit can consume significant amounts of water to reach the playoffs again. With the use of this action 43 liters of raw water consumption is saved per a kilogram of hydrophilic cotton.

In the autoclave unit due to the sensitivity of the health care waste water using has no place at all stages. But it is possible to use recycled water in some sections of this unit such as washing units and one can also prevent the water loss.

In autoclave unit due to lack automatic closing system of water, mostly the water is over flown and water is wasted. Therefore, it is also possible in this unit to minimize the up or down of the water and its loss by installing level control sensors [6] [10].

In the completion unit of the fabric can be used modern methods such as dry cleaning cloth and its preparation to produce sterile gauze bandages. Since at this moment 40 liters of water is used per kg of fabric, it is possible to reduce the water consumption at least 70 – 80 percent. Thus the water consumption falls from 40 liters to 12 liters.

Research suggests that dry cleaning of cotton is economically affordable, aside from that, there is no water in some areas to be used in cotton processing. And thus the application of innovative technologies not only helps to protect water resources from industrial units but also prevents industrial units from being shut down [2] [5].

Future research in this field can be focused on sewage treatment methods of these units and /or use of hybrid systems in refining or fabric washing methods [12].

Because research has shown that technology-based membrane systems are the best methods that can be replaced by the old methods.

In addition, hybrid treatment techniques, including absorption and absorption by a nano-filtration can also be effective to improve the quality of produced effluent. Moreover, additional treatments include ion exchange systems can apply the effluent such that it has the ability to returning back to the production line and the use of recycled water from the processing steps [1] [9].

Therefore, the water consumption in the production line is similar to a closed cycle and water usage is reduced to its minimum. Of course there are still more strategies, such as modern cotton-processing methods includes dry cleaning of remaining ingredients which can be done to reach to a greater amount of water saving.

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- Fundamental goal
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- Center on shortening results - bound background information to a verdict or two, if completely necessary
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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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ISSN 9755896