THE INDONESIAN JOURNAL OF
BUSINESS ADMINISTRATION
Vol. 1, No. 6, 2012: 343-352

PROPOSED QUALITY IMPROVEMENT OF LIQUID ORGANIC FERTILIZERS "HERBAFARM" TO MEET NATIONAL STANDARDS IN INDONESIA

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Abstract—*Indonesia is a country with abundant natural resources. It is supported with arable land and tropical climate that make agriculture, plantation and forestry in Indonesia is growing. In agriculture, fertilizer is an important commodity. Fertilizers are divided into two types, namely organic fertilizer and inorganic fertilizer. Understanding the importance of fertilizers for agriculture, the Ministry of Agriculture Republic of Indonesia has set standards of quality for fertilizers in Indonesia. Quality is usually defined as the characteristics of a product that include performance, reliability, and ease of use. This thesis background is report from Soil and Plant Laboratory Inc. about the lowness macronutrient content of Herbafarm. This final project is focused to find the cause of decreased quality of Liquid Organic Fertilizer "Herbafarm" and proposed the method to improve its quality. Methodology that used in this thesis is examining every activities related to production of its fertilizer. Beside that, it also analyzed the Quality Control data, measures production process performance from the data with the Control Chart, and use a fishbone diagram method to analyze the root problem. Also providing quality improvement proposals to meet the National standards by using Six Sigma approach. Result from the study is found inadequacies raw material warehouse that cause the decrease of raw material content. The proposed recommendation is to build new raw material warehouse according to minimum standard of material handling.*

Keywords: Organic fertilizers, Quality, Raw material, Six Sigma.

I. Preface

1.1. Background

In agriculture, fertilizer is an important commodity. Fertilizer acts as a provider of macro and micronutrients to the plants. If the amount of fertilizer used in a plant not properly fulfilled, then it will affect crop production. Essential nutrients needed by plants are macronutrient, which consists of the elements nitrogen, phosphorus and potassium. These elements has its own functions for plants:

• Potassium is derived from the K_2O, it has function in the process of photosynthesis, transport of assimilation, enzymes and minerals, including water. Improve plant resistance to disease. In plants that lack the element potassium, the stems and leaves become limp or fall, dark green leaves bluish green, the tip of the leaves turn yellow and dry, brown spots appear on the leaf.

• Nitrogen, derived from NH_3, This function is to stimulate plant growth as a whole because the nitrogen is part of the plant cell itself. Nitrogen serves for the synthesis of amino acids and proteins. Stimulate vegetative growth (green) like a leaf. If plants lack the element nitrogen, the plants will show symptoms of growth is slow / stunted, yellowish green leaves, narrow leaves, short and straight, old leaves quickly turn yellow and die.

• The element phosphorus, derived from P_2O_5, has another performance for the plant, which serves to transport energy metabolism in plants, stimulate flowering and fruiting, stimulates root growth, stimulating the formation of seeds, as well as stimulate cell division and enlarge the plant tissue. Elemental phosphorus-deficient plants will show symptoms of the formation of

fruit / seeds and reduced, stunted, or reddish-purple leaves. (Ardi, 2009).

Thus fertilizer is a major requirement for farmers to increase the number and quality of their crop production. According to the origin of raw materials, fertilizer can be grouped into two types: inorganic fertilizer and organic fertilizer. Inorganic fertilizer is a fertilizer derived from synthetic materials that have specific content of certain nutrients, such as ZA, TSP, etc. that many in the market.

While the organic fertilizer is the fertilizer that largely or entirely composed of organic material from plants or animals that have gone through the engineering process, can be solid or liquid that is used to supply organic material to improve the physical, chemical, and biological soil.

Understanding the importance of fertilizers for agriculture, the Ministry of Agriculture of the Republic of Indonesia has set standards of quality for fertilizers in Indonesia, in this study is devoted to organic fertilizer. Most organic fertilizer manufacturer in Indonesia is the Small and Medium Enterprises (SMEs), so it is difficult to obtain production data. With the Minister of Agriculture Regulation No. 02/Pert/HK.060/2/2006 about organic fertilizers and soil fixer, is expected to spur the organic fertilizer manufacturers to produce quality fertilizer, so the quality of organic fertilizer will be able to compete with inorganic fertilizers.

1.2 Company Profile

PT. Sido Muncul stems from a domestic industry in 1940, managed by Ms. Rahkmat Sulistio in Yogyakarta, and assisted by three employees. The growing demand for herbal medicine is to have more practical packaging, encourage her to produce herbal medicine in a practical form (powder), along with his move to Semarang, the company was founded in 1951 under the name Sido Muncul simple which means "the dream come true" to the location on Jl. Mlaten Trenggulun.

During its development, the factory is located in Jl. Mlaten Trenggulun was no longer able to meet the huge production capacity due to increasing market demand, and in 1984 the factory moved to the Small Industry in Environment Jl. Kaligawe, Semarang. Due to the large market demand, the plant began equipped with modern equipment and a growing number of employees. In 1997 PT. Sido Muncul move its production plant to Bergas-Ungaran, with 29 ha area was inaugurated by the Minister of Health and Social Welfare of the Republic of Indonesia, dr. Achmad Sujudi on November 11, 2000. The plant site can be seen at the figure below.

Figure 1.1. PT. Sido Muncul Plant at Ungaran-Central Java

Environment and Process Division of PT. Sido Muncul stood since 1 November 2000. The Objective is to address environmental issues that may arise as a result of the production process. In addition the Environment and Process Division also handles the processing and utilization of side-product of PT. Sido Muncul. Environment and Process division initially consisted of four main units, namely units of solid waste, liquid waste unit, unit of essential oils and water treatment unit. Along with the development of environmental and process technology division developed into a productive division with the establishment of the units that produce products that are processed from the side of PT. Sido appears. The units include units of bioethanol and bio-organic fertilizer unit Herbafarm. Figure below is shown the Liquid Organic Herbafarm product.

Figure 1.2. Liquid Organic Fertilizer "Herbafarm"

II. Business Issue Exploration

2.1 Conceptual Framework

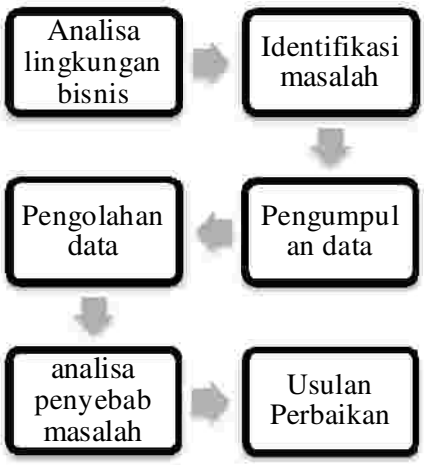

Figure 2.1. Final Project Conceptual Framework

2.2 Business Issue Analysis

In agriculture, fertilizer is a major component for farmers. Fertilizer can be said is a source of food for plants and soil. So there is no substitute for fertilizer products.
Government of Indonesia in 2000 promote organic farming, but the socialization is still lacking, so that many farmers are still use inorganic fertilizers compared with organic fertilizer. It makes a big component of this effect for the survival of Liquid Organic Fertilizer "Herbafarm".

With organic farming held by the Government of Indonesia, began to appear organic fertilizer manufacturers who produce fertilizer to meet the needs of agriculture in Indonesia.

The Indonesia Ministry of Agriculture was make organic fertilizer standards in Indonesia. Purpose of the quality standard is made so that users can obtain a quality organic fertilizer and organic fertilizer manufacturers will make a quality product.

The regulation is based on the Regulation of the Minister of Agriculture Permentan No. 02/Pert/HK.060/2/2006 an updated to Permentan No. 28/Permentan/SR.130/5/2009.

The Liquid Organic Fertilizer "Herbafarm" has ingredients that follow the Ministry Regulation, which is:

Table 2.1. The Liquid Organic Fertilizer "Herbafarm" Content

Nutrien	Content
Organic C	6.93%
Nitrogen (N)	2.24%
P2O5	1.91%
K20	1.81%
Zinc (Zn)	0.002%
Copper (Cu)	2.49 ppm
Mangan (Mn)	0.003%
Cobalt (Co)	0.74 ppm
Boron (B)	0.100%
Molybdenum (Mo)	<0.001%
Iron (Fe)	0.028%

Also its enriched with microbes, the number of microbes are deducted below:

Table 2.2. The Microbes Content of Liquid Organic Fertilizer "Herbafarm"

Microbes	Content
Azotobacter sp	$3.5x10^6 – 3.5x10^8$ cell/ml
Azosprillum sp.	$1.4x10^7 – 1.4x10^9$ cell/ml
Phosphate solubilizing bacteria	$2.34x10^5 – 2.34x10^7$ cell/ml
Lactobacillus sp.	$1.34x10^4 – 1.34x10^6$ cell/ml
Pseudomonas sp.	$5.35x10^3 – 5.35x10^5$ cell/ml
Cellulolytic bacteria	$1.12x10^6 – 1.12x10^8$ cell/ml

The Production Process of Organic Fertilizer "Herbafarm" is started from the raw material, stillage production. Stillage is a side product from the bioethanol production. Bioethanol in PT. Sido Muncul is used to extract the herbs to make Jamu. Along the ethanol production, it will result side product with large quantities. The stillage still contained useful minerals, so it can be recycled into fertilizer.

The production of stillage can be seen at this diagram below.

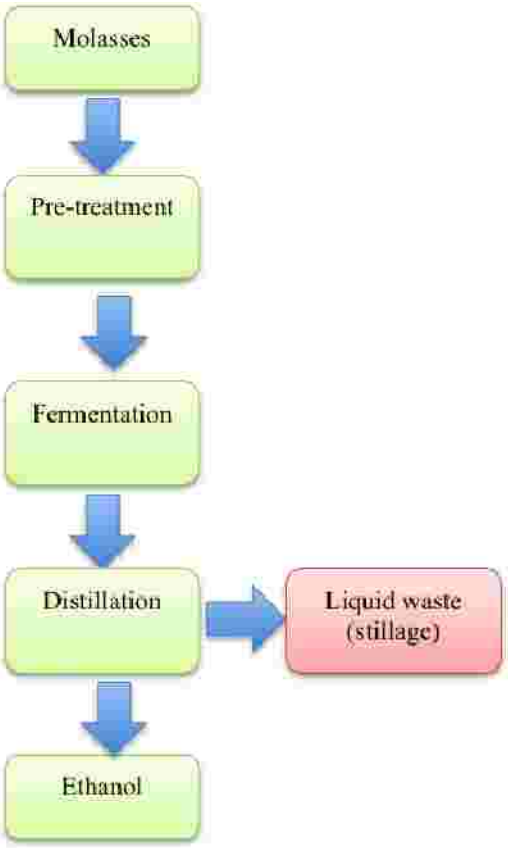

Figure 2.1. The Production Process of Ethanol

Stillage that have been produce will be transported to the fermentation tanks of fertilizer production. The process of fertilizer production will be explain below:

• Fermentation 1: adding dry cow rumen, which is a source of microbes. Then do filtering; this fermentation process is takes 2 weeks.

• Enrichment of microbes: microbes cultured from the master sheet. Microbial entered is Azotobacter, azosprillium, lactobacillus, pseudomonas sp, bacteria and cellulotic phosphate solvent. During the breeding process is given the nutrients in the form of urea, NPK fertilizer and molasses. Breeding process lasted for 2 weeks in anaerobic conditions.

• Fermentation 2: added results of microbial from microbial enrichment process, as well as the added phosphoric acid, potassium, and ammonia as microbial nutrients. The fermentation process takes place 2 weeks.

• filling: Liquid Organic Fertilizer packed into the bottle. The filling process is using a pipe flow of torrent directly to the filling machine. This machine has 8 faucets, which can fill 1liter bottle every minute. So in 1 minute will produce 8 bottles.

• Capping: installation inside and outside of the bottle cap. Performed by using a capping machine. For one round, can put up 10 bottles.

• Labeling: installation label on the bottles that have been closed, using a labeling machine.

• Packing: is the last process. Bottles that have been labeled put in a cardboard box containing 12 bottles of 1-liter sizes. Then closed with cardboard sealer machine.

Quality is an important issue of a product. To make a quality product, we need serious handling from the beginning of the process, which is the selection of raw material, handling and storage of raw materials, production process and conducted a routine control of the product.

2.3. Problem statement

From the analysis of quality control is known that Liquid Organic Fertilizer "Herbafarm" does not meet quality standards set by the Ministry of Agriculture of the Republic of Indonesia

III. Business Solution

There are many methods in quality improvement. Such as Total Quality Management and Six Sigma.

3.1. Alternative Business Solution

According to Reid and Sanders, Total Quality Management is an integrated quality improvement method from all level of organization. It has focus on identifying the root cause (root cause) of quality problems, and improves on the source. The concept of TQM is summarized in the table below

Table 3.1. The TQM concept

Concept	Main Idea
Customer focus	To identify and meet customer needs
Continuous improvement	A philosophy of never-ending improvement
Employee empowerment	Employees are expected to seek out, identify, and correct quality problem.
Use of quality tools	Ongoing employee training in the use of quality tools
Product design	Products needs to design to meet customers expectation
Process management	Quality should be built in the process; sources of quality problem should be identified and corrected.
Managing supplier quality	Quality concepts must be extending to company's supplier.

TQM have several tools to identify and correct quality problems, such as:
1. Cause-and-effect diagrams, or also known as the fishbone diagram. The head is the problem faced, while his bones are the possible causes of the problem, which is obtained from several sources.
2. Control Chart, Chart is used to evaluate whether the work done is match to the expectation. On this chart set an upper limit (UCL) and lower limit (LCL), if a process is in the limit, then process it into the expectations and quality issues. If there is data beyond the boundary, then there are quality issues.
3. Flowchart, a schematic diagram that shows step by step in the process or operation. By describing the steps that occur, can be seen clearly how the operation works and where problems can arise.

Other method is Six Sigma, which is introduced in 1980s by Motorola (Meyer, 2007). Six Sigma combines the problem-solving methodology, focusing on optimization and cultural change. The concept can be abbreviated to DMAIC (Define, Measure, Analyze, Improve, Control). Table below is describing the Six Sigma phase. (Tayntor, 2003)

Table 3.2. Six Sigma's DMAIC Concept

Phase	Objective
Define	Identify problem and customers; define and prioritize the customer's requirement; define the current process.
Measure	Confirm and quantify the problem; measure the various steps in the current process; define desired outcome.
Analyze	Determine the root cause of the problem; propose solutions
Improve	Prioritize solutions; develop and implement highest benefit solutions
Control	Measure the improvements; ensure that process improvements are sustained

3.2. Business Solution Analysis

In this study will use Six Sigma methods to analyze business solution of the problem of quality of Liquid Organic Fertilizer "Herbafarm".

1. define

In this study found a quality problem of the product Liquid Organic Fertilizer "Herbafarm". This quality problem is indicated by a report from a laboratory in the United States who examining the content contained on Liquid Organic Fertilizer "Herbafarm" also found a significant difference from the macronutrient content of the fertilizer contained, if it compared to the standard accepted by the Ministry of Agriculture, the data can be shown in appendix 3A. In addition, data from quality control of Liquid Organic Fertilizer "Herbafarm" also found the varying levels in each of his batch. Most of the data showed a decrease in macronutrient levels. In the standard nutrients from Liquid Organic Fertilizer "Herbafarm", the levels of Nitrogen, Phosphate and Potassium in succession on nutritional standards are 2.24%, 1.91% and 1.81%, while the results of quality control is performed on products obtained average data potassium in the last two years, in 2010 and 2011 were 0.85% and 0.3%.

From the explanation above, we can see there is a difference between the product and the National Standards, even with the Company's standard.

2. Measure

Measure phases are the stages in order to clarify and quantify the problems that occur within the company. Problems experienced by the environmental and process division of PT. Sido Muncul is the quality of Liquid Organic Fertilizer "Herbafarm" under the minimum standards set by the Ministry of Agriculture. To measure this, carried out data collection in support of this fertilizer product quality.

Data used in this study was the analysis of data quality control laboratory PT. Sido Muncul. The data-level element contains the macronutrient content of Liquid Organic Fertilizer "Herbafarm" from 2010 to 2011.

From the average levels of potassium, followed by analyzing its use of control charts. In the control chart limits specified above figure (Upper Control Limit) and the lower limit (Lower Control Limit) with a standard deviation of 0.5%, Set number 2 for UCL because of standards set by the Ministry of Agriculture, that for potassium levels <2. If more than 2 may be

considered that the organic fertilizer has been added synthetic materials. While the LCL is set at 1 is intended to levels not too small, and can provide the function of the plant. the following data is UCL and LCL:

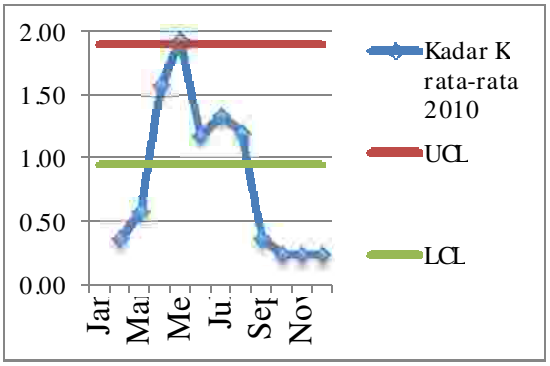

Figure 3.2. Control Chart Potassium Levels 2010

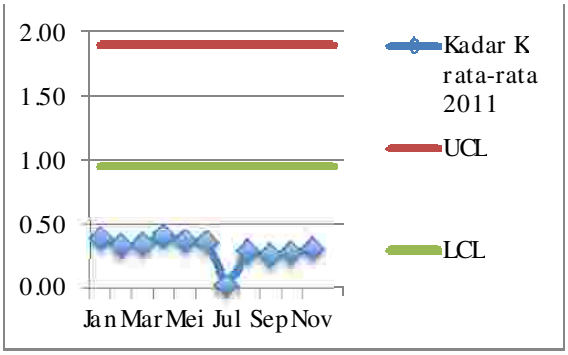

Figure 3.3. Control Chart Potassium Level in 2011

From the graph above, it is known that much deviation from a predetermined control limits. In 2010 there were fluctuations in levels, where there are levels beyond the limit and those that are included in the limit, ie in April, June and July 2010 while in the month of May 2010 found the average K content of 1.9 where the figure was slightly outside the upper control limit. In 2011 all of the data showed K levels well below the control limit. Cpk calculation results obtained from the K levels in 2010 gained 0.2 points, where the figure is much the standard Six Sigma, the data can be seen in appendix 3B. From these data indicate that there are quality issues on Liquid Organic Fertilizer "Herbafarm".

3. Analyse
phases analysis, use Cause-effect diagram method, known as Ishikawa diagram or fishbone diagram to determine on which part of the potential as a root of the problem.

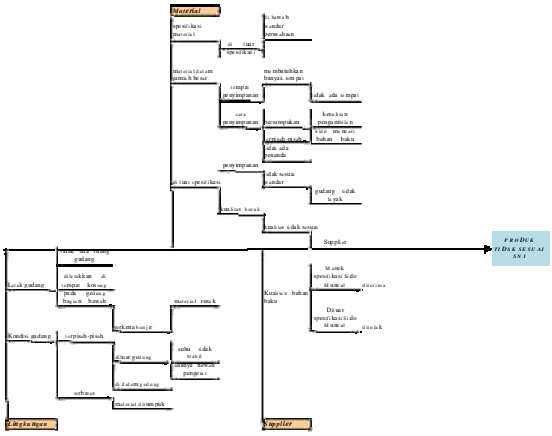

Figure 3.4. Fishbone Diagram

Based on the above diagram, do the groupings of the problems that arise in six categories: materials, processes, employees, environment, machinery, and suppliers. Explanation of Fishbone diagram will be outlined as follows:

• Material: Environment and Process Division in the use of the material used as raw material has certain specifications. Materials to be used must first pass the quality test by the Quality Control Division of PT. Sido Muncul.

Standard raw material source of nitrogen, phosphate and potassium are used Division of Environment and Process for producing Liquid Organic Fertilizer "Herbafarm" is as follows:

N: Liquid, clear colors, levels of 20-25%
P: Liquid, clear colors, levels of 80-85%
K: 190g/kg levels, the water content of 1%.
Of results quality control of raw materials is found levels below the standards required. That is the raw material potassium, which are results of 39.46 levels, which remain in use for production.

Purchases of raw materials in large quantities, it can be good for the purchase of large quantities will save expenses, things to note from the purchase of raw materials in bulk is the way its storage. Storage of raw materials should be appropriate to the nature and the characteristics of the raw material.

Table 3.3. Raw material Characteristic

Raw Material	Physical and chemical characteristic	Storage & handling
Phosporic acid (KH_2PO_4) (sciencelab.com, 2005)	White powder, odo slightly, corrosive, hygroscopic, not compatible with acis, bases, alkali pH: 4.5 melting point: 253°C boiling point: NA Solubility: soluble in cold water, insoluble in alcohol.	In cold, dry. Keep away from water / moisture. Stored in covered and kept away from incompatible materials
Nitrogen (NH_4OH) (seastarchemicals.com, 2011)	Fluid, strong smelling, colorless, stable at room temperature, forming explosive components with halide salts and heavy metals. Boiling point: 27.2°C pH: 10.6 solubility: soluble in water	Store in a cool, dry place, away from the heat, sparks and flame. Store in a well-ventilated area, do not store in direct sunlight. Keep away from incompatible materials. Keep the container tightly closed. Empty containers may contain hazardous residues. Do not add any other material to the container. Do not smoke while handling or consumption of food.
Potassium (KOH) (Sciencelab.com, 2005)	White granules, odorless Boiling point: decomposition temperature of 1384°C Melting point: 380°C pH: 13 Solubility: soluble in hot water and cold water	Store in a tightly closed container, make sure the cool place (not more than 23°C), and the area has good ventilation.

But in fact, the storage of large amounts of raw materials that provide an obstacle, that it takes a greater place. From the result in the field, it was found that the raw materials are stored in a way that just laid on the floor and covered with short shelf materials are stacked in such a way, and placed apart from one material to another, as shown in Figure 3.5 and 3.6 below.

Figure 3.5. Real Condition of Raw Material Warehouse

Figure 3.6 .Raw material placed outside

• Environment: The location and storage conditions also determine the quality of an item. The location of the raw materials warehouse is in the same building with the production of organic fertilizer granules. But with the amount of raw material rice bran, which is voluminous and thus require a large space. At the end of bran is placed outside the warehouse. (Vina, 2012).

Building granular fertilizer production are at the bottom, so it is feared will be exposed to flooding. The flood occurred in 2010 and 2011 in December, so worrying to store raw materials there.

warehouse conditions can change the physical and chemical properties of raw materials if it is not adapted to the standards of the raw materials. From the current, separate warehouse and its limited field. The separate layout, will make it difficult to find raw materials, as well as if the raw materials placed outside the building, will be exposed to the external temperature and the threat of attack rodents such as mice. With limited space, making the raw materials should be stacked up, it can be difficult when taking raw materials and the packaging material is damaged.

Figure 3.7. Torn Sack of material

• Supplier: the other party to give effect to the production process and the product is a supplier or dealer. Suppliers who work with PT. Sido Muncul to have a product that goes in the standard specification of raw materials. If the product is delivered not in accordance with the specifications, then the PT. Sido Muncul have right to reject the product.

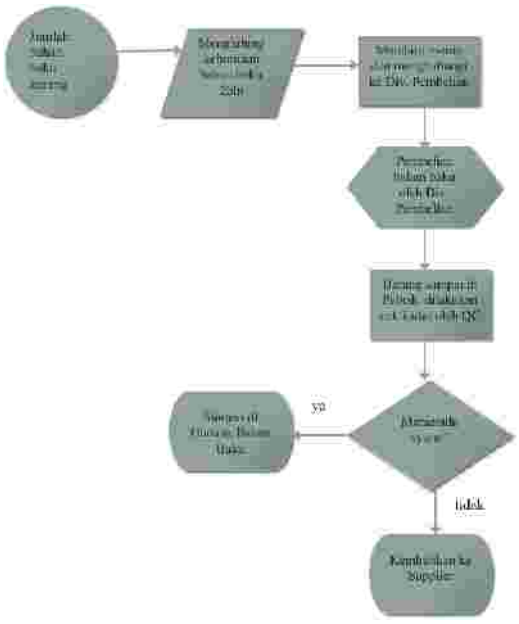

Figure III.8 . Process of Ordering Raw Material

From the analysis of raw material quality, variations in the potassium and microbial decomposers, wherein the potassium levels fluctuate, there is a very high level, exceeding 1160.5 ppm, but there is also a yield of 39.46 ppm. While the results of analysis of bacterial decomposers, some products are analyzed do not contain bacteria. It is an important things because it will affect the results of finished products.

4. Improve

From the previous analysis can be seen that the cause of decreasing levels of macronutrient of Liquid Organic Fertilizer "Herbafarm" it is not selective provider of raw materials supplier selection and quality control tools are limited. Raw materials are received and sent by the supplier used by PT. Sido Muncul.

Corrective measures that need to be performed are as follows:

1. Improve the condition of the raw materials warehouse in accordance with the standards in accordance with the requirements of the storage of each material.
2. For raw materials that have a short shelf life, made the purchase in accordance with production needs, to avoid the loss of quality raw materials.

5. Control

Control stage makes Six Sigma different with other quality improvement methods.

This stage is enabled to control the changes that have been planned to coincide with corporate

objectives. Not only the quality control employees do control, but also it has become the duty of all employees to participate in the program control to achieve maximum results.
At this stage we need a control metrics that can be used to control each stage of the process that occurs in the production of Liquid Organic Fertilizer "Herbafarm" and the control carried out on an ongoing basis. The example of control metrics can be seen at the picture below

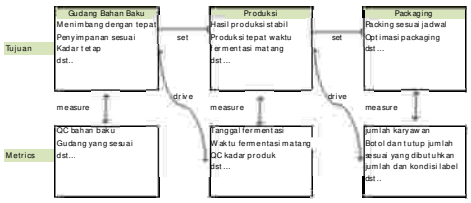

Figure 3.9. Control Metrics Example

IV. Conclusion & Implementation Plan

From the analysis, the conclusion of this final project is there any problem in raw material handling which make the quality of Liquid Organic Fertilizer “Herbafarm” decrease, so that makes it not meet the National Standards.
Recommendations for the better Fertilizer quality are to make a warehouse building and manage the raw material according to their type and with FIFO method.

To implement quality improvement Liquid Organic Fertilizer "Herbafarm" to meet the standards of the Department of Agriculture, the plans drawn up as follows:
A. Raw warehouse
1. Determine the location of raw material warehouse. The location must near to the production area, so the raw material transportation to production site is easy.

Figure IV.1. Alternative location of Raw Material Warehouse

2. Designing a warehouse of raw materials in accordance with the requirements of the storage material. The sketch and sights are available at figure IV.2 until IV.4

Figure IV.2. Proposed Sketch of Warehouse

Figure IV.3. Proposed Front Sight of Warehouse

Figure IV.4 . Proposed Back Sight of Warehouse

3. Move raw materials from the old warehouse into a new warehouse.

B. Quality of Raw Materials
1. Provide information to the warehouse employees, supervisors and formulators regarding the handling and storage of raw materials respectively.
2. Store raw materials in the warehouse in accordance with the requirements of the standard material.
3. To check periodically for natural raw materials, which have a short shelf life.
4. Be checked by physical and chemical quality of raw materials before production, to maintain that there is no change in levels.

C. Laboratory of Quality Control

1. Environment and Process Division shall submit to the PT. Sido Muncul to establish its own Quality Control team.
2. Environment and Process Division shall submit to the PT. Sido Muncul to complete the instrument in accordance with the requirements of quality control measurements of product quality Organic Fertilizer.
3. Purchase of tools that support the control of product quality and selection of Organic Fertilizer Quality Control team. Quality Control team personnel do not have to come from new employees, but can also employees of Quality Control of PT. Sido Muncul specifically assigned to work on quality control of products - products Herbafarm, and especially here is Liquid Organic Fertilizer.

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