International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

# Application of Internet of Things for Implementation of Smart Milk Vehicle

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**Abstract -** Milk as a commodity finds its utility in every aspect of human life. Starting from birth to until old age, milk is consumed by every human on earth. Various movements in India such as white revolution has enabled the self-sustainability of milk in India a reality. Many farmers and companies are involved in this job sector and India is the largest producer of milk accounting to approximately one-fourth of total world's production. Thus, it becomes important to have the highest quality of milk for its consumption. Milk is often transported from producing farms to processing plants. The journey between these points can be of several kilometres. Hence, it is of paramount importance to have assurance of milk quality not getting spoilt during transportation. Farmers and companies often face problems in tracking the details of milk during its transportation, therefore it is required to encourage them to adopt new methods to ensure timely deliveries of milk and save them from economic losses occurring due to spoiling of milk. In this paper a smart wireless tracking tool based on Internet of things (IoT) has been designed and proposed to perform various operations on the milk vehicle. The proposed mechanism consists of various sensors to determine various parameters of milk quality. To execute the whole process, it is equipped with Raspberry Pie 2 model B hardware. The main features of the tracking device are tracking of level of $P^H$, moisture, humidity, $CO_2$ and to make the device self-power reliant it is equipped with solar cell that will power the Raspberry Pi controller. To capture the image of milk inside the tanker an infrared camera is fitted with a PIR sensor to ensure the closure of lid of the tanker.

***Keywords- Milk, Sensors, Smart controllers, wireless sensor network, automation and interfacing.***

## 1. INTRODUCTION

Milk production in one of the main sources of livelihood of people in and around the world. In India production of milk is done almost in each and every village. It is one of the main occupation of people, accounting their livelihood in its production. Farmers produce milk with utmost purity and in high yields and sell them to large dairy companies, which processes the milk for the consumption of common people. Transportation of milk is one of the most important steps in processing of milk and is the direct link between producers and consumers. Unfortunately, farmers do not have an approachable methodology to track their milk during transportation. It often leads to economic losses occurring due to various factors such as spoilage of milk quality due to uneven handling of milk, theft of milk or delay in delivery timings. For getting better results for their produce, monitoring the milk is a vital task for farmers. There is an urgent need to develop a robust, realistic and economically feasible solution in milk transportation due to various constraints associated with it.

The milk transportation mechanism in the previous years used simple equipment's like tankers, cans or mini crates. These are used in predetermined manner without having concern about weather conditions nor $P^H$ levels, causing ambiguity in condition of milk. By incorporating various controlling and sensing techniques such as using air cooled tankers and chilling facilities in transportation vehicles, the reliability in quality of milk has increased to some extent but the question of real time tracking and analysis of milk during transportation remains far of a dream to be achieved. This arises the need for wireless technologies and automation in transportation of milk. Various sensors are interconnected to monitor a physical entity with the help of a Wireless Sensor Network (WSN). These WSNs are acknowledged to be network of immense power to process and collect data, having low power requirement and low cost. They offer a temporal resolution and high spatial solution to monitor milk through various sensor nodes attached on the vehicle, the nodes are connected wirelessly and a multi-hop communication system is used for sending data [1]. There has been a rapid development in the sector of information and computer technologies and in wireless sensor networks enabling the maintenance and functioning of agriculture-based industries far easier than it used to be. This revolution has been further strengthened by Internet of Things (IoT) in major industries and sectors all over the globe. IoT produces actions that contains information, which is produced after many things interact with each other [2]. The main advantage of IoT is that we can remotely determine the working status of an equipment like ON/OFF, OPEN/CLOSE etc. Involvement of IoT technology with farmers will allow them to connect their devices to the internet and will help them increase their productivity.

This Paper is arranged in the following manner. Works related to the already existing system has been portrayed in section 2. Section 3 contains the design and analysis of the proposed system using Raspberry Pi 2 model B. The analysis of hardware and its investigation is done in Section 4. In Section 5, conclusion has been drawn.

## 2. RELEATED WORKS

Authors in [3] have analyzed the role of IoT in agri-food industry and have demonstrated its disruptive role in shaping the future of the industry. Authors in [4] have spoken about recent trends and advancements in the IoT-enabled smart village paradigm. Furthermore, they have presented taxonomy for IoT enabled smart villages based on the offered services, communication technologies, network types and consumer electronics (CE). In their study, several communication technologies such as RFID, 6LoWPAN, and IEEE 802.11p support the smart village applications. To determine the factors affecting the quality of milk authors in [5] have used the methodology of spectroscopy. They devised that milk solids are effectively detected in the range of 400-700nm range. To exploit this band, they have utilized a mini spectrometer Hamamatsu C12880MA, which operates in the 340-850nm range. The proposed milk sensing technology is not only effective but also costs just under five hundred dollars. Authors in [6] have designed a IoT system to analyze and determine the quality of milk by using Arduino and various sensors. Microbial activity of milk is determined by gas sensor. The authors have focused much on salinity level of milk, since it is an important parameter in determination of quality of milk. The authors have also designed a database management system to manage the details of information produced by the board. Authors in [7] have designed a system to distribute milk effectively based on data mining, K-means clustering based routing to reduce the spoilage of milk. The authors have emphasized the use of $P^H$ sensor to acquire data to determine the best possible route of milk distribution. When it comes to freshness of food, author in [8] has worked on a mechanism to determine oxygen and ammonia levels in a food item. According to the author ammonia and oxygen are also important factors that have to be considered while deciding the quality of food. The author has developed a program which decides whether a food is spoilt or not by taking the inputs of level of ammonia and oxygen in ppm. Authors in [9] have clearly laid out available wireless communication protocols for communication in IIoT devices like ZigBee, BLE for short range, under low power category and LTE, LTE-A for longer ranger under high power category and have also explained the merits and de-merits of each. Compared to the existing related research works, in this paper, we propose a much-simplified system design that does not rely on internet and works well with cellular technologies like SMS for exchange of data. In developing country like India, availability of high-speed internet in distant regions and villages still remains a unanswered question. The proposed device will have different types od sensors and data collected from the sensors will be sent to the desired operator. The data collected from the sensors will provide information about different parameters about milk which in turn will help improve the quality of the milk. Monitoring the milk itself is not a complete solution but there are number of other factors that affect the quality of milk to a great extent. These factors include the cleanliness of the storage unit which can be controlled by examining the levels of $P^H$ and harmful gases. Secondly, we need to ensure that the lid of the storage unit remains intact once closed and this problem can be overcome by deploying a PIR sensor. This will also eliminate the fear of theft of product during the transportation.

## 3. DESIGN OF SYSTEM

The different monitoring areas of a wireless sensor network consists of various tiny objects known as sensor nodes. They are assigned to fetch a particular data and complete the task assigned to them. Some of the sensors are Milk Density Sensor, Temperature Sensor, Gas Sensor, Viscosity Sensor, Humidity Sensor, Moisture Sensor, UV sensor, $P^H$ Sensor and a PIR sensor. These determine important parameters and any minor alteration in their properties can cause degradation in the quality of the milk.

The proposed device that can be fit in any milk carrying vehicle is shown in fig. 1. It consists of transmitter section and the monitoring section. The fig. 1. Is drawn in the form of block diagram to clearly illustrate the model of device. The transmitter section of the model consists of a Raspberry Pie 2 Model B with various sensors such as Milk Density Sensor, Temperature Sensor, Gas Sensor, Viscosity Sensor, Salinity Sensor, Humidity Sensor, Moisture Sensor, UV sensor, $P^H$ Sensor, PIR sensor, Liquid Crystal display and a camera. The receiver section consists of a normal Keypad mobile or a smartphone.

The details of the components used in the proposed system are as follows.

### 3.1 Raspberry Pi 2 Model B

Raspberry Pi 2 Model B hardware uses Raspbian as its recommended operating system. The software is a free to use operating system based on Debian. It is a high-performance controller with a low power consumption for interfacing with various sensors and performing the specific task based on the code written on it.

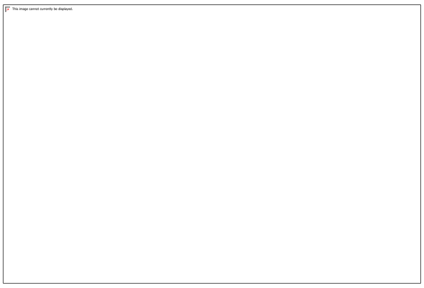

**Fig -2:** Raspberry Pi 2 Model B

### 3.2 Milk Density Sensor

A specific milk density sensor is not available in the market at viable prices. This limitation can be overcome by using a pressure sensor. Pressure is a function of density of the liquid and the depth at which it is measured. Thus, the pressure sensor can be placed inside the tank at a particular depth and the density can be measured correspondingly.


**Fig -3:** BMP180 Digital Pressure Sensor

### 3.3 Temperature Sensor

The temperature sensor selected here is LM35D Analog Temperature sensor. It can be calibrated directly into centigrade. It has low power consumption and a lower output impedance.

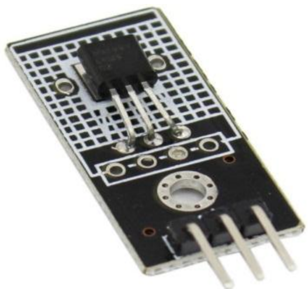

**Fig -4:** LM35D Analog Temperature sensor

### 3.4 Gas Sensor

We have selected MQ135 Gas sensor module. It has high sensitivity to gases like Ammonia, Sulphide and Benze steam. The cost of module is low and it is suitable for application in different areas. Its application includes detection of ammonia, aromatics, sulfur, benzene vapor, and other harmful gases/smoke, gas detection. It has been tested in the concentration rang of 10 to 1000 ppm.

**Fig -5:** MQ135 Gas sensor module

### 3.5Viscosity Sensor

Typical Value of viscosity of milk is around 2.0. To monitor the value of milk around it, I used a typical sensor shown below in fig. 6.

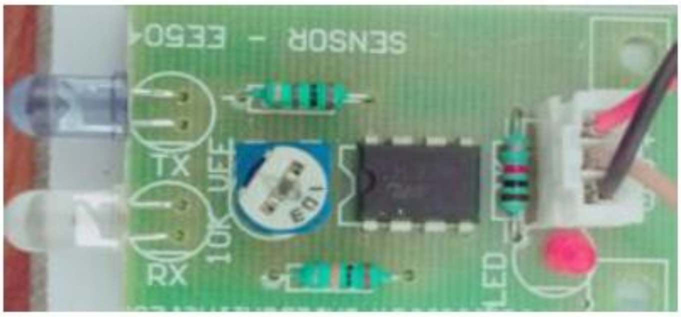


**Fig -6:** Viscosity Sensor

### 3.6 Salinity Sensor

Salinity has adverse effect on the milk quality and can cause significant degradation of milk. A typical Salinity Sensor used in the proposed system is shown below in fig. 7.

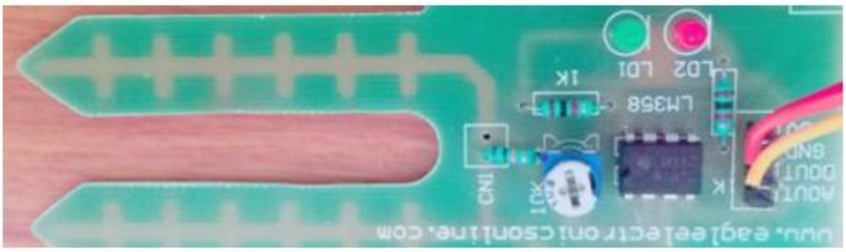


**Fig -7:** Salinity Sensor

### 3.7 Humidity Sensor

Higher levels of humidity are of concern to quality of milk. The sensor measures the Humidity level of the atmosphere in which it is placed. A typical Humidity sensor used in the proposed system is shown in fig.8.

**Fig -8:** Humidity Sensor

### 3.8 UV Sensor

The Ultra-Violet Sensor detects the ultra-violet rays and uses its intensity to convert photo-current to voltage. The sensor comes equipped with an internal amplifier. A typical UV sensor is shown in Fig. 9.

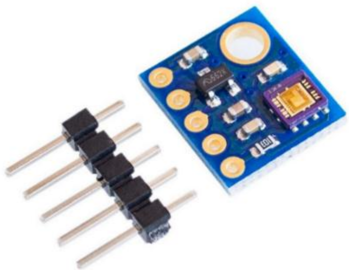

**Fig -9:** UV Sensor

### 3.9 $P^H$ Sensor

The threshold $P^H$ level is around 6.9. Thus, it becomes important to track the level of the $P^H$. A typical apparatus used is shown in fig. 10.

**Fig -10:** $P^H$ Sensor

### 3.10 PIR Sensor

Passive Infra-red is used here to ensure the closure of the lid of the milk tanker. It detects the motion of bodies coming in front of it. A typical PIR sensor used is shown in fig. 11.

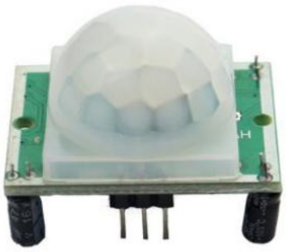

**Fig -11:** PIR Sensor

### 3.11 LCD Display

It is used to display the value of relevant quality parameters. A typical LCD used in raspberry pie is shown in fig. 12.

**Fig -12:** LCD Display

### 3.12 Infrared Camera

It shows the image of the milk stored inside the tanker. Since, the tanker is closed we utilize the IR camera to be able to look in dark. It directly displays on the LCD screen. A typical Infrared camera used in the proposed system is shown below.


**Fig -13:** Infrared Camera

### 3.13 GSM Module for Information Facilitation

To update the farmer or the company officials about the current status of the milk. We need to send them Text-message. We use paid services to ensure uninterrupted communication between the milk tanker and the people. A typical GSM Module used in the proposed system is shown below. It sits right above the Raspberry Pi.

**Fig -14:** GSM Module

To make the Raspberry Pi self-reliant for power, we have included the utilisation of a Solar Panel. We have used here a Power Management Board ("HAT"), a Solar Panel of capacity of 40W, a battery with a capacity of 5000 mAh. A housing case will be used to protect it from external environment.

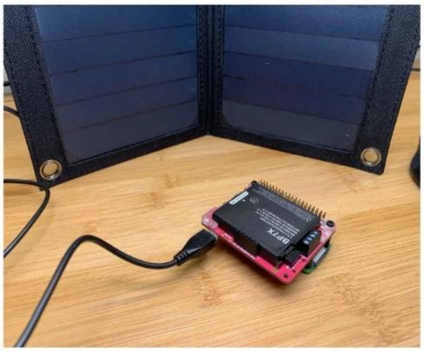


**Fig -15:** Solar cell and Battery

## 4. System Implementation and Analysis

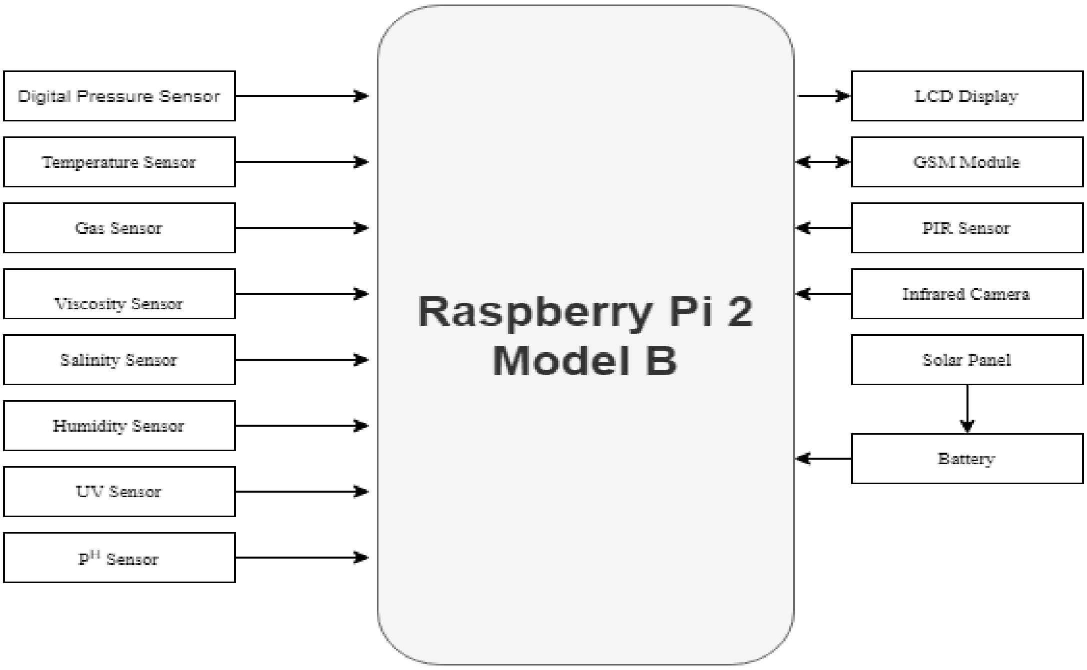


**Fig -16:** Implementation of the proposed Smart Milk Vehicle Components

The Proposed System can be placed inside the tanker of the vehicle to ensure its complete utility and protection. To study the performance of the system, a small dairy farm in Motihari, Bihar has been chosen and the destination of the milk has been selected to Patna, Bihar. The system was fit inside the Lid of the tanker with the solar panel placed behind and connected externally to the Microcontroller. The camera will provide images to the LCD fit inside the driver's cabin. The system is set to send updates on $P^H$ Level, Humidity Level, Temperature Level, and Viscosity levels every half an hour in the journey. The farmer holds a basic feature mobile and gets updates based on Text messages. The images of the tanker are shown in fig.17. The milk used was grade-A level full fat milk.

**Fig -17:** Milk Tanker

The distance between Motihari to Patna via Muzaffarpur is around 160 KM. The route is shown in fig.18.

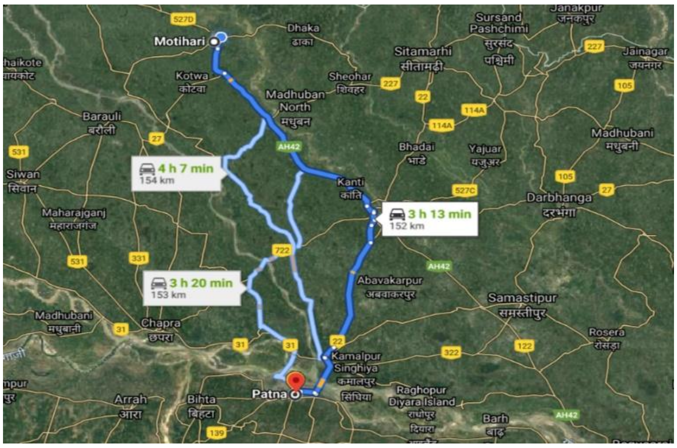


**Fig -18:** Distance Map

It takes around 3 hours to complete the journey. So, we will have 6 readings till it reaches the destination. Count of readings have been increased to get more accurate image of the quality of the milk. Various Plots of milk quality are shown in fig. 19.

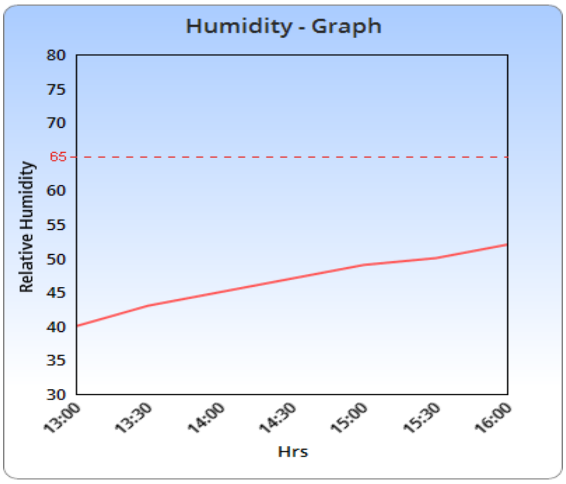


**Chart-1:** Humidity Chart

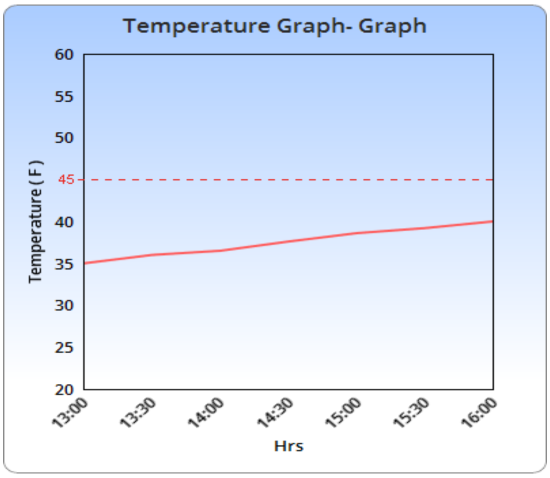


**Chart-2:** Temperature Chart

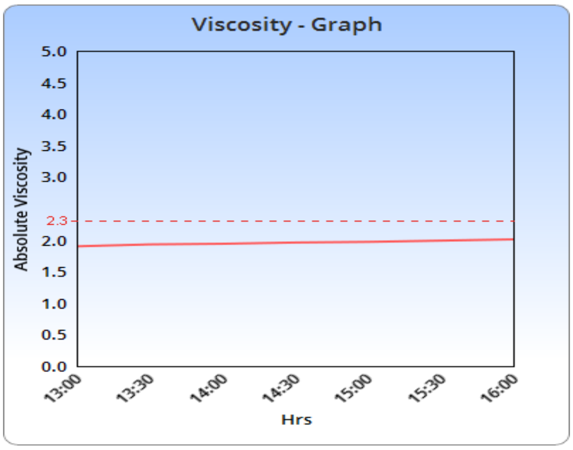


**Chart-3:** Viscosity Chart

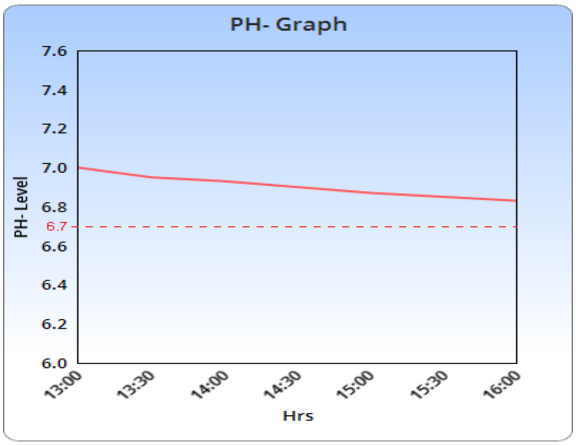


**Chart-4:** PH Chart

The Charts show the values of various parameters at different time period. The graphs also have a threshold line indicating the spoilage level barrier. Table containing all the relevant values is shown in Table -1.

**Table-1:**

| Sl. No | Time | Humidity | Temperature | Viscosity | PH |
|---|---|---|---|---|---|
| 1. | 13:30 | 40 | 35 | 1.90 | 7.0 |
| 2. | 14:00 | 43 | 36 | 1.95 | 6.98 |
| 3. | 14:30 | 46 | 37 | 1.98 | 6.95 |
| 4. | 15:00 | 49 | 38 | 2.00 | 6.94 |
| 5. | 15:30 | 52 | 39 | 2.05 | 6.92 |
| 6. | 16:00 | 54 | 40 | 2.10 | 6.80 |

The text message received is shown in fig. 20

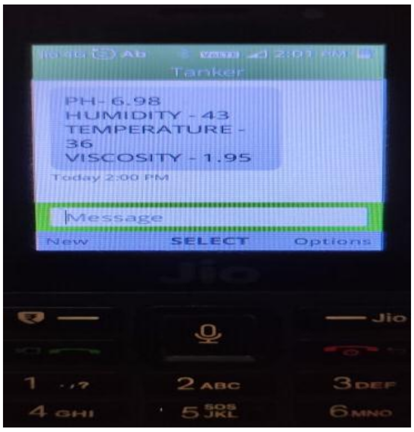


**Fig-20:** Text Message received on Mobile

## 5. CONCLUSION

In this paper, the proposed system is designed and implemented and is not only cost effective but also serves a very important role in testing and tracking the milk. With the help of various sensors attached to the system, it is able to provide accurate insights of the quality of the milk. Monitoring the milk helps reducing the spoilage of milk and increase productivity of farmers. The system is user-friendly and is reliable due the robust mechanism of the microcontroller. The system could further be enhanced by using various other techniques to make the system even more efficient like using alarms for speed detection of the vehicle to prevent accidents. The alarm system can also be used to send emergency updates in case of milk crosses the prescribed threshold value.

## ACKNOWLEDGEMENT

I would like to express my very great appreciation to Mr. Anupam Kumar for sharing his precise and insightful knowledge to my project. He being the Unit Head of the Dairy plant, spared his valuable time in helping to arrange the milk tanker and guiding me through its working.

I would also acknowledge the staff of Mother Diary Fruits and Vegetable Private Limited, Motihari for enabling me to visit their plant and observe their plant operations

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