Hand Held Device for Detection of Pesticides using NDVI

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ABSTRACT
Population of the earth is soaring day by day but the resources are limited. To fulfill the need of food the farmers continuously strive to increase the production of crops not only by natural fertilizers but also with the help of artificial chemical fertilizers and pesticides. Chemical fertilizers, pesticides, and herbicides are used to protect the crops from any kind of harm caused by pests, insects and fungi. These may lead to the increase in production but in turn degrade the quality of food. Due to excessive use of fertilizers and pesticides these chemicals enter the food chain and ultimately cause biomagnifications. We are ingesting the same products and they adversely affect our health. Hence we need a portable device which can analyze the organic components of the eatable substance. This research focuses on determining the organic as well as inorganic components of the eatable so that the consumer may know whether the eatable is fit for consumption or not. This research comprises of an electronic device which would detect chemicals present with the help of infrared light. The device would show the ratio of organic components to inorganic components. The consumer can use this ratio as a benchmark to buy the eatables fit for consumption.

Keywords
Microcontroller PIC18F452, Infrared sensor, ADC, LCD, Photodiode

1. INTRODUCTION
India stands second in the production of vegetables and fruits after China with 13.4% of total world's production. Among the total population of 1.25 billions, approximately 110.7 million comes under the category of farmers. Also, India ranked fourth in the world in the production of agrochemicals and fertilizers. Survey conducted by various institutes indicates that 50-70% of vegetable and fruit production are contaminated with pesticide residues [1]. The increasing population of India, results in higher demand for food, indeed decreases in land for farming. Hence to fulfill the demands of increasing population, food is adulterated to get more quantity in short period of time. Also, pesticides on crops are use by farmers above the legal residue limit that is defined by WHO.

Fruits and vegetables are considered as main food commodity and highly nourishing component in the human consumption [2]. We eat fruit and five vegetables daily, but are they really safe to eat? What about chemicals that farmers used to keep their crops free of charge from pests? Are these chemicals resided on the food we eat? The answer is YES, food generated is health hazardous and toxic to human health due to large use of pesticides. The most of the fruits and vegetables present in the markets are those which are either artificially grown or are infected with several chemicals used for pests. Such type of chemicals and artificial ripeners are like calcium carbide/ethephon and oxytocin respectively [3]. Authentication and adulteration determination in fruit juices is the important research area. Over so many decades the industries are benefited due to large use of cheap chemicals and the adulteration chemicals over the honest ingredients on food [4].

On the subject of the meaning of pesticides some people have contradictory facts. Dictionary define pesticides as any substances that are used to kill, prevent or repel any pest that interfere with the production, processing, storage or marketing of food, agricultural commodities, wood and wood products or unnecessary species of plants or animals causing harm during or otherwise and which may be administered to animals for the control of insects or other pests in or on their bodies. Although pesticides are highly effective on pests and have some benefits but they can reside in an eatable and cause danger to human health. The use of pesticides will increase in future if proper measures are not taken..

2. RELATED WORK
While surveying it has been concluded that Horiguchi et al. describes method to detect pesticide particles floating in water with the help attenuated total internal reflection method. ATR method is applicable to various state samples, such as solid, liquid and powder, by contact with ATR prism, therefore commonly-used for surface analysis. The experiment was done with picking up sprayed pesticides by sheets (collecting sheets) and measuring these collecting sheets surface. Water-sensitive paper was used, which is used for traditional drift test, and polyethylene (PE) sheets as collecting sheets. Samples were taken containing different amount of pesticide on the sheets and using Infrared light was irradiated on the samples [5]. The phenomenon of total internal reflection was also observed in the water because the molecules absorb the light. Qualitative analysis is done by obtaining infrared absorption pattern. Fourier transform of IR spectrum of total reflection a model was made to evaluate pesticide concentration. The principle of this work was that the amount of IR light absorbed can be shown by absorbance, and is explained by Lambert-beer law method. The absorption is equivalent to concentration of the pesticides. Thus the qualitative analysis was possible. It requires on spot spectroscopy apparatus and also requires a system which calculates FT of ATR and plus the hardware for sensors is also required. So, to detect pesticides a large apparatus was required and cost was also much more than a common man can afford. Bhandari et al. presents method for the analysis of satellite image based on Normalized Difference Vegetative Index(NDVI) [6]. The method uses the technique of multi spectral remote sensing to read signatures of different objects. The NDVI is a commonly used technique for measurement of crop health in agricultural applications. Because of the spatial variability in soil properties, different locations in a field may require different amounts of nitrogen to achieve high yield. After obtaining the point information of NDVI, with the help of Geostatistics, the spatial continuity surface is produced and the crop characteristics are presented to develop the precision

agriculture. Different values of threshold of NDVI are used for generating the false color composite of the required objects. The simulation results show that the NDVI is highly useful in detecting the surface features of the visible area which are extremely beneficial for municipal planning and management. The vegetation analysis can be used for the situation of unfortunate natural disasters to provide humanitarian aid, damage assessment and furthermore to device new protection strategies. This method makes use of remote sensing data technique to find spectral signature of object. Different values of NVDI represent different land feature and vegetation cover can be identified with the help of NDVI values. False color composite images are made to show different land forms. The main aim of this study was to find vegetative index of different covers and classify them according to NDVI. The NDVI is calculated as :

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Riczu et al. [7] survey on intensive apple orchard is done by three spectral instruments. Based on these spectral surveys some investigation results were analyzed by different software environment and the normalized differential vegetation index map was created. Similarly on the test site spectral point sampling was created. Spectral results were compared and strong linear correlations were detected between each spectral measurement. All these measurements were done at the early senescent stage (after the first autumn frost in the year) of the apple plantation. The applied instruments gave information about vigor condition of fruit trees in a non-destructive way.

Green Seeker 505 is used for calculating the NDVI. It is an active remote sensing tool and has an internal light for calculating the NDVI. The sensor emit light (red band – 656 nm and near infrared band – 774 nm) from the rectangular window onto a crop's canopy. The reflected light from the canopy is focused on a detector behind the circular window.

2.1 Proposed Work

There are several papers proposing various methods for implementing different techniques. Various techniques that are used for pesticide detection are Gas Chromatography (GC) with ECD, High Performance Liquid Chromatography (HPLC) along with Mass Spectrometry (MS), SVM, electro analytical techniques, chemical and biosensors, spectroscopic techniques and flow injection analysis (FIA) [8]. All these methods need lot of time for sample preparation and gives result after some duration of time. These limitations result into need for better detection of pesticide toxicity in agricultural products. The various aspects for the need of this method are:

- Its effects on human health for long time.
- Its great effect on environment.
- Pesticide's storage facilities.
- Moving of pesticide into food chain.
- Its high concentration causes toxicities.
- Probability to make a test in field conditions.

Considering all above points in concern, there is a need of developing a system which should gives results accurately and on the spot. A new rapid and easy device has been made for the analysis of chemicals in our food.

A promising alternative to classical methods is the development of a method that must check different factors affecting fruits and vegetables. The main significance of this work is its:

- High select and sensitive nature.
- Relatively low cost of manufacturing.
- Miniaturization potential.
- Facility of portability.
- Efficient, rapid in nature.
- Simple for the control of food processing.
- Higher quality and safety.
- It can be easily used and is of very small in size.
- It is less in weight, hence require less space.
- The cheaper and time undemanding testing is the biggest advantages of the device.

Detection of pesticides residue at the level established by the Environmental Protection Agency (EPA) is always a challenge. Chromatographic methods with various different detectors had been traditionally used in pesticide residue analysis because of their efficiency, selectivity, reliability and sensitivity. Nonetheless, they are time demanding and laborious, and needs costly equipments and skilled technicians to interpret data. Over the last few years, significant attention has been given to the development of sensor for the detection of pesticide residue as a promising alternative. A proposed sensor system is a self-contained device that contains sensing element (e.g. IR sensor) to recognize the analyte and a transduction element (ADC) to convert the analog signal obtained into digital required form. Furthermore, lower cost, easy design and smaller size; make them excellent contender for the development of portable device. The key objective of this proposed work is design and development of sensor based system to detect the pesticide residue in food.

In this research, we have to design the circuit so that a number of sensors can be interfaced with the circuit, so that we can obtain average value for our subject. Firstly power circuit is designed, giving output of 5V to microcontrollers, sensors and LCD. Two IR sensors and photodiodes are interfaced with microcontroller performing the function of transmitter and receiver respectively. Then a filter circuit is designed to amplify the received input from the IR circuit. It amplifies the input and gives distortion free amplified output to the microcontroller. The ADC in microcontroller converts analog input into digital signal and NDVI is calculated by the given formula:

(NDVI= B-A/A+B)

Where A= Red light band B= Infrared Band The values for different subjects were calculated and matched with their true values and error was calculated.

3. HARDWARE DESCRIPTION

Fig.1 shows the block diagram of the proposed work. It consists of various hardware modules such Microcontroller PIC18F452, LCD, Photodiode, IR sensors, battery source.

A. Photodiode

A photodiode is a device which acts as a light detector when light of sufficient intensity falls on it. Photodiode convert light energy into voltage or current. It is a semiconductor device having p-n junction and an intrinsic layer between p and n layer. When light of sufficient intensity falls on it produce photocurrent by generating electron hole pair. Photo current produced is directly proportional to the intensity of absorbed light. The process is called inner photoelectric effect. It works on the three modes.

- Photovoltaic mode or zero bias mode.
- Photoconductive mode.
- Avalanche diode mode.

B. *Light Emitting Diode*

The LED is called as Light Emitting Diode, a type of diode. As it has similar characteristics to a PN junction diode, which means it pass the current in forward bias mode and block the current in reverse direction mode. In the forward biased mode, electrons from the conduction band get recombine with the holes from the valence band, which release sufficient energy which emits monochromatic (single color) of light. Then we can also say that when operated in forward biased mode LED converts electrical energy into light energy. The LEDs are made from different semiconductor compounds such as Gallium Phosphide (GaP), Gallium Arsenide (GaAs), etc. And all these compounds are mixed together at different proportion and produce a different wavelength of colour. Thus, the colour of LED is determined by the wavelength of light emitted.

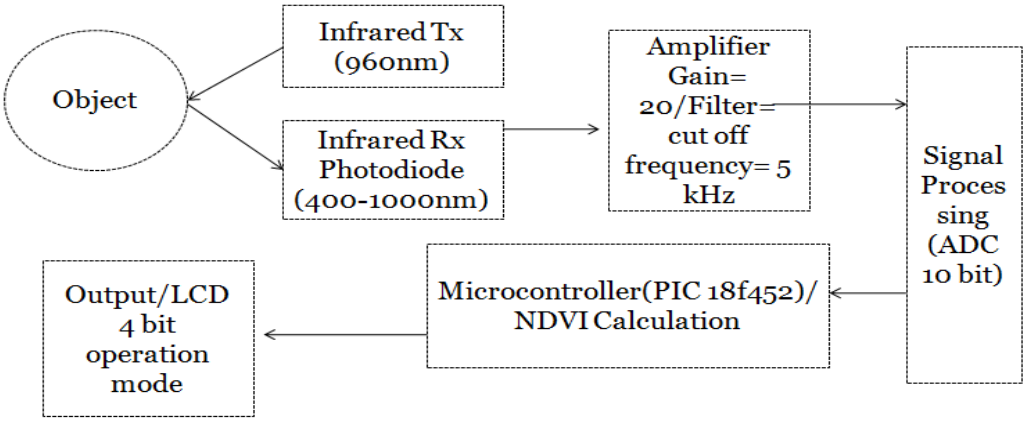

Fig 1: Block Diagram of proposed work

4. SOFTWARE DESCRIPTION

Embedded system links both hardware and software. Software, part of a system has equal importance as the hardware part of the system. This chapter explains about the software development tool used in this research work. It also explains about the flow chart and programming concept .The software used are

- MPLAB.
- Mikroprog suite for PIC

MPLab IDE V8.91 is used for programming for programming of the PIC microcontroller. To compile the code we used, PIC C 18 compiler that is an integral part of the IDE. It is very easy for the programmer to develop applications with the help of powerful MP Lab tool. PIC microcontrollers are widely used in the world. Programming of the PIC microcontroller in C is easier as compared to assembly

language because of the availability of large libraries. MP Lab provides many features including third party compilers.

Mikroprog suite for PIC is used in this project for burning the program in pic18f452 microcontroller. This is an advanced burner. The configuration bits can be set on burning of program.

A. Flow methodology

The main goal of the proposed system is to design and development for the sensor system for pesticide detection. The methodology used to achieve that is explained further with a flow chart in figure 2.

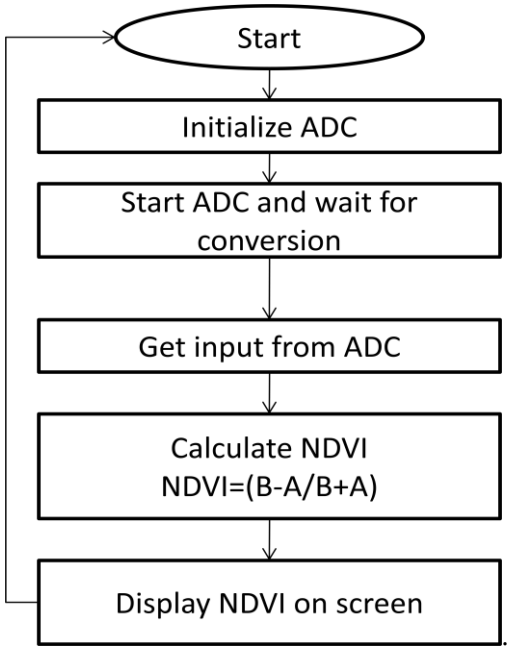

Fig 2: Flow diagram of proposed work

5. RESULTS AND ANALYSIS

The development of a device for the detection of organic/inorganic Components using NDVI is discussed this section: A sample is placed in front of IR emitter and subject is exposed to IR rays as shown in Fig. 4 and then the photodiodes collect the reflected rays send the value to micro controller. The input signal is converted in corresponding voltage values by ADC in PIC18F452. The difference between transmitted IR light by IR sensor and received by photodiode gives us the ratio of organic content to inorganic content of the subject. The value is converted into NDVI by the given formula and the value is displayed as shown in Fig.5. The NDVI is calculated by the formula:

$$NDVI = \frac{\text{NIR} - \text{RED}}{NIR + RED}$$

The graph in figure 6 shows NDVI values calculated by the device for organic as well as inorganic subjects. The red line shows NDVI for inorganic subjects and blue line is for organic subjects.The figure 7 shows graph for homegrown organic oranges and infected oranges. The infected oranges shown deviation from their true organic content value.

The blue line shows graph for homegrown oranges and red line shows oranges infected with pesticides is shown in Fig.7

Fig 3: Basic System setup

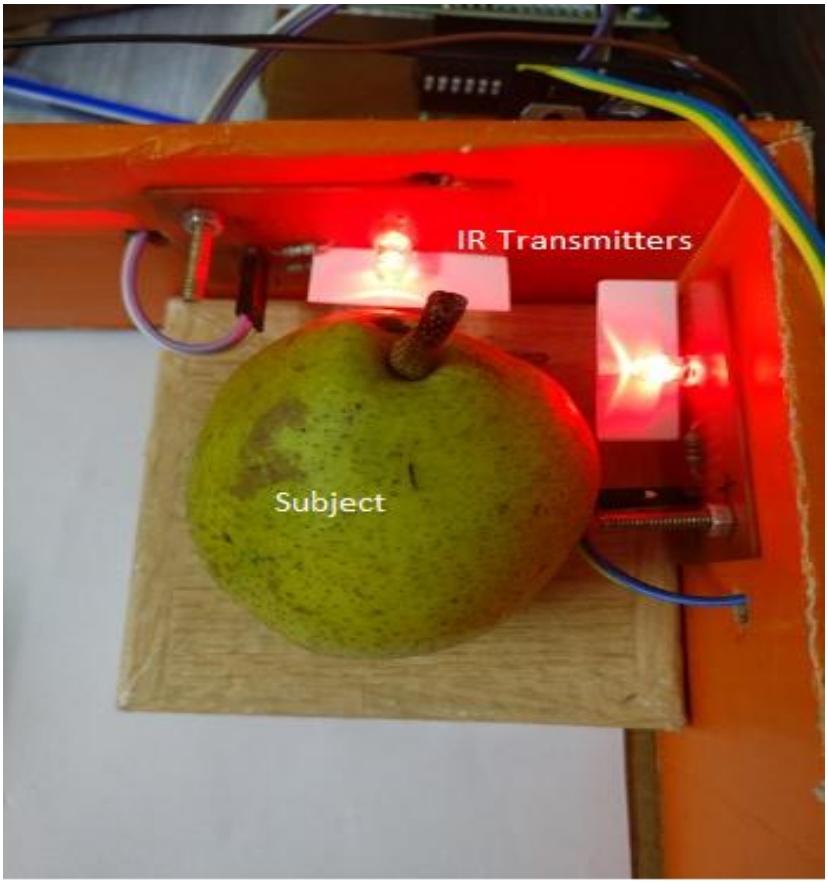

Fig 4: Throwing NIR on subject

Fig 5: Calculation and display of NDVI

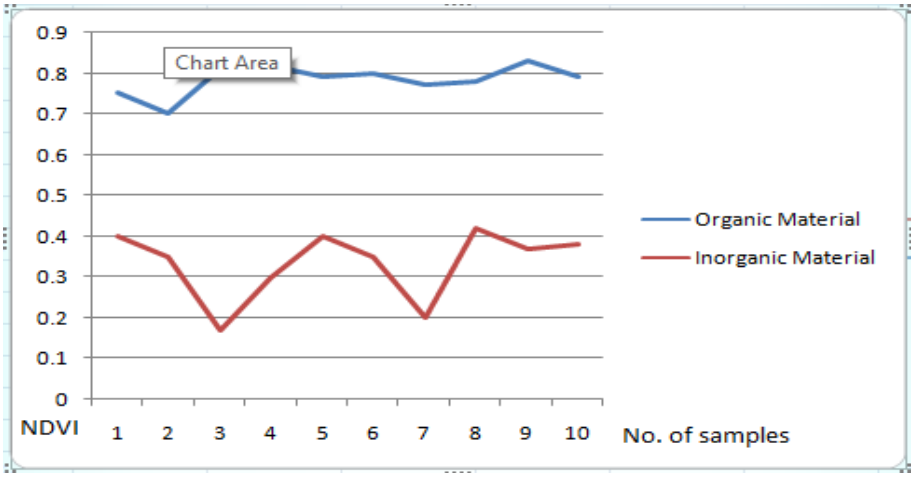

Fig 6: Diagram for Organic vs. Inorganic subject

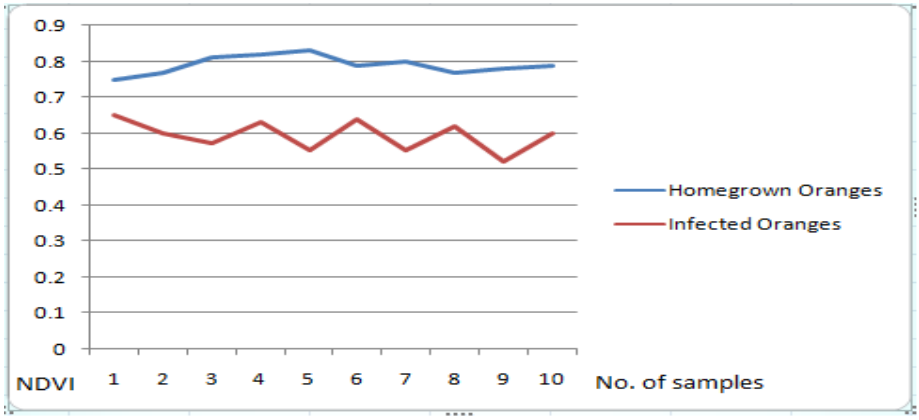

Fig 7: Homegrown vs. Infected Oranges

B. Error Correlation

The NDVI values were checked for various organic subjects and their true organic value was checked with original values calculated by various researches and error correlation was calculated for the hardware by subtracting obtained values from original values by using Pearson Correlation.

The NDVI values were checked for various organic subjects and their calculated organic value was checked with original values calculated by various researches and error correlation was calculated for the hardware.

NDVI value calculated	Organic content of the oranges
0.75	0.79
0.70	0.76
0.81	0.80
0.82	0.80
0.79	0.80
0.80	0.78
0.77	0.80
0.78	0.80
0.83	0.80
0.79	0.75

$x_i = 0.784$ $y_i = 0.788$

Pearson's Correlation Coefficient

Sum of squares for x = $SS_{xx} = 0.01284$

Sum of squares for y = $SS_{yy} = 0.003196$

Sum of cross product = (0.008)(0.076) = 0.000608

Correlation Coefficient = 0.0949112950

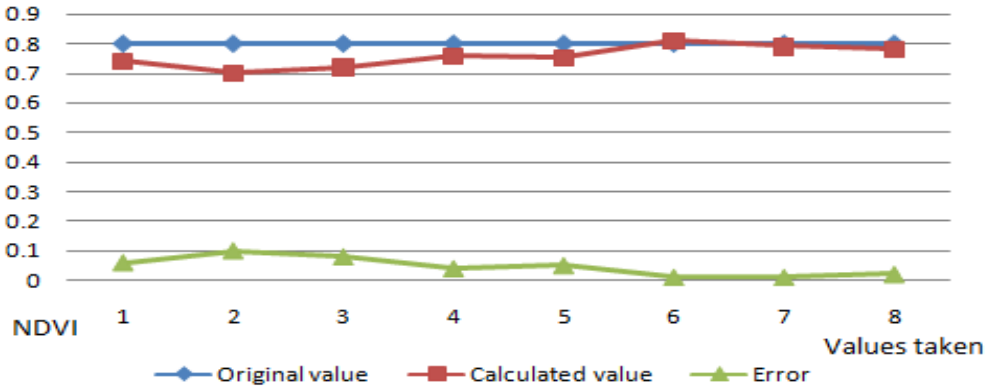

Fig 8: Error correlation of the device

6. CONCLUSION AND FUTURE SCOPE

The device developed uses Near Infrared rays to check organic content of the subject. It is quite cheap and reliable method to check eatables whether they are fit for human consumption or not. It will spread awareness among the masses and help them with their day to day eatables. The NDVI is obtained without taking any samples or cutting or damaging the eatables. So, we can check any eatable like in our houses, ports, shops, etc, without any fuss. It gives us values of organic content instantly So, no more waiting for the lab results. It is better than any device made in past for the detection of pesticides. The error coefficient of the device has been checked thoroughly by comparing it with original values and error is quite low if we are using the device for day to day use. The current methods for checking quality of food need a lot of time and proper lab equipment is required. It is cumbersome method and it is not possible to check each and every sample before eating. So, here comes our equipment in play. It is quite cheap as a single manufactured unit can be made under Rs 4000/- and it can be bought by majority ofl the masses in the country. It can work simply on AA batteries at potential of 5v. It is handy and can be used by anyone to make sure their food is not infected. This way it can help many people to eat safe.

In future we can increase number of IR sensors and take their average for more reliable NDVI calculation. Costly and better sensors can be used for less error and efficient calculation. Samples of eatables can be taken and few more parameters can be added to check the pesticides. Further advanced sensors can be used for detection of other harmful chemicals like weedicides, fungicides, etc

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