I.J. Engineering and Manufacturing, **2016, 2, 10-17**
Published Online March 2016 in MECS (http://www.mecs-press.net)
DOI: 10.5815/ijem.2016.02.02

Available online at http://www.mecs-press.net/ijem

Design and Development of Pesticide Residue Detection System using EC and pH Sensor

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Abstract

Increase in the population of India, results in higher demand for food as well as decrease in land for farming. Hence to fulfil the increased demand, food is adulterated to get more quantity in short period of time. Moreover, pesticides in crops are using above the legal maximum residue limit by farmers to gain more profit in lesser time. Although pesticides are highly effective on pests but they can reside in an environment. Among the class of organophosphate pesticides, chlorpyrifos is widely used in vegetables. Chlorpyrifos has toxic effects on the human body particularly on brain and nervous system. In this paper, design and development of sensors for pesticide residue detection using parameters like electrical conductivity, pH etc are proposed. It was found that the relative percentage deviation between the value of conductivity in pesticide free samples and the pesticide containing samples of bitter gourd, bottle gourd and tomatoes are 31.4%, 10.7% and 19.09% and also between pesticide free samples and market samples are 33.5%, 8.7% and 16.56% respectively. This large variation among different samples shows the presence of pesticide residue. Hence, the method can be successfully used for the detection of pesticide residues in vegetable samples. The proposed sensor system is easy, rapid and time undemanding method. So, this electronic device can also be used to check impurities in any other liquid like water, milk etc.

Index Terms: Pesticide residue, electrical conductivity, pH, chlorpyrifos, vegetable samples.

1. Introduction

India ranked second in the production of vegetables and fruits after China with 13.4% of total world's production. Among the total population of 1.21 billions, there are total of 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 as well as decrease in land for farming. Hence to fulfil the demands of increasing population, food is

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adulterated to get more quantity in short period of time [2]. Also, pesticides in crops are using above the legal maximum residue limit by farmers to gain more profit in short period of time. Although pesticides are highly effective on pests but they can reside in an environment [3].

Organophosphate is one of the most applied class of pesticide in agriculture. Among the class of organophosphate pesticides, chlorpyrifos is widely used in vegetables. Chlorpyrifos has toxic effects on the human body particularly on brain and nervous system [16]. For these reasons, need of detection method for the determination of traces of harmful pesticide like Organophosphate compound is must. The use of pesticides will increase in future if the good and sophisticated methods are not adopted.

The paper is organised in 4 different sections explaining every aspect of project. First section gives the brief introduction regarding the pesticide use and mostly used pesticide on vegetables. Second section describes the previous work performed in the field of developing different techniques. It includes brief description of all types of technologies and techniques that are used in research work. Third section explains the proposed methodology using block diagram and flow chart. The results with tables and flow charts are discussed in the last section.

2. Related Work

There are various analytical methods present for the detection of pesticides in the samples of different fruits and vegetables. The traditional methods are the laboratory methods like several types of chromatography techniques such as gas chromatography, liquid chromatography [7] and further joining different techniques such as mass spectrometry [18] with it to get better results. Chromatographic methods attached to selective detectors had been traditionally used in pesticide analysis because of their sensitivity, selectivity, reliability and efficiency. Nonetheless, they are time-demanding and laborious, and needs expensive equipments and highly-skilled technicians.

Some other methods are also there like some flow injection analysis, enzyme linked immunosensor assay and some electro analytical techniques [12]. All these methods need lot of time for sample preparation and gives result after some duration of time. This limitation results into the need of better detection of pesticide toxicity in agricultural products. At last, the present techniques that are the biochemical methods used for the detection of particular chemicals are like bioassay for pesticide detection and different types of biosensors are also there [16].

Over the last decade, significant attention has been given to the development of sensor for the detection of pesticide residue as a promising alternative. A promising and most reliable alternative to previous laboratory techniques is the development of sensors to check different parameters like electrical conductivity, pH etc affecting fruits and vegetables. A proposed sensor system is a self-contained device that integrates sensing element (e.g. pH sensor, temperature sensor, LDR and TDS sensor) that recognizes the analyte and then ADC is used to convert the analog signal obtained into digital required form. Furthermore, their low cost, easy design, smaller size, safety and time undemanding analysis is the biggest advantages of the device and make it excellent candidate for the development of portable device.. The basic working of proposed system is explained further.

3. Proposed Work and Methodology

3.1. Reagents and material:

Chlorpyrifos is (phosphorothioic acid,O,OdiethylO- (3,5,6-trichloro- 2- pyridyl) ester in IUPAC nomenclature) used for the analysis.

In this research, various samples of tomato, bitter gourd and bottle gourd were collected randomly from the market. Total 5 samples of each were taken for the analysis of pesticide residue. The samples from the local organic farm are also being collected to set reference value.

3.2. Apparatus: The proposed system consists of two main units:

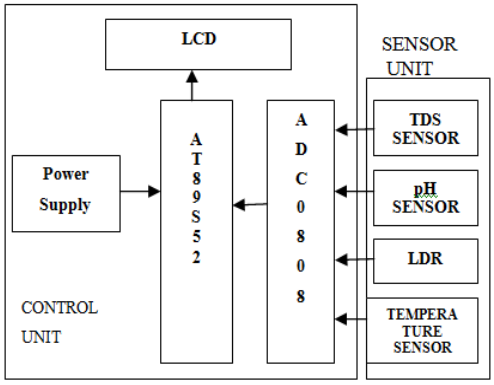

Fig.1.1. Block Diagram of Pesticide Residue Detection System.

Sensor unit: Samples were analyzed for total dissolved solids using TDS meter, pH was measured by pH meter, Temperature is monitored using thermistor and then the thickness of the solution is analyzed using Led and LDR unit.

Control unit: It consists of microcontroller, ADC, power supply and LCD. In control unit, there is analog to digital converter which will receive the signal coming from the different sensors at the sensing end. The microcontroller will process the data and display the result on the LCD which is also interfaced with the microcontroller.

3.3. Procedure:

The method to detect pesticide residue in various samples are explained under:

- ***Application of the method on pesticide free samples***

Vegetable samples of tomatoes, bottle gourd and bitter gourd were planted without application of pesticides was cleaned thoroughly and juice was extracted from them. A solution is made by mixing the extracted juice of vegetable with the fixed amount of distilled water. Then mix the few drops of aqueous solution of chlorpyrifos in the solution thoroughly and wait for the 2 minutes. The solution was monitored at ambient temperature. After that, values of three different sensors were evaluated for different samples of vegetables for pesticide residue by varying the amount of pesticide in solution.

- ***Application of the method on pesticide containing samples***

Samples of tomatoes, bottle gourd and bitter gourd were collected from the farms having pesticide sprayed on them and then the juice was extracted from them after cleaning it with distilled water. After that, the detection method is carried out as same as for pesticide free vegetables. The experiments were also carried out on all other vegetable samples.

- ***Validity of method***

The validity of the proposed system is checked by carrying out the experiment for pesticide residue on both the pesticide free samples as well as pesticide containing samples. The results obtained from both the experiments were compared and get plotted on graph with respect to pesticide concentration.

3.4. Methodology:

The main goal of the proposed system is to design and development for the sensor system for pesticide detection. The samples of vegetables that we have taken can be examined for pesticide residue using various methodologies. The methodology used in this proposed work is explained further with a flow chart is given below:

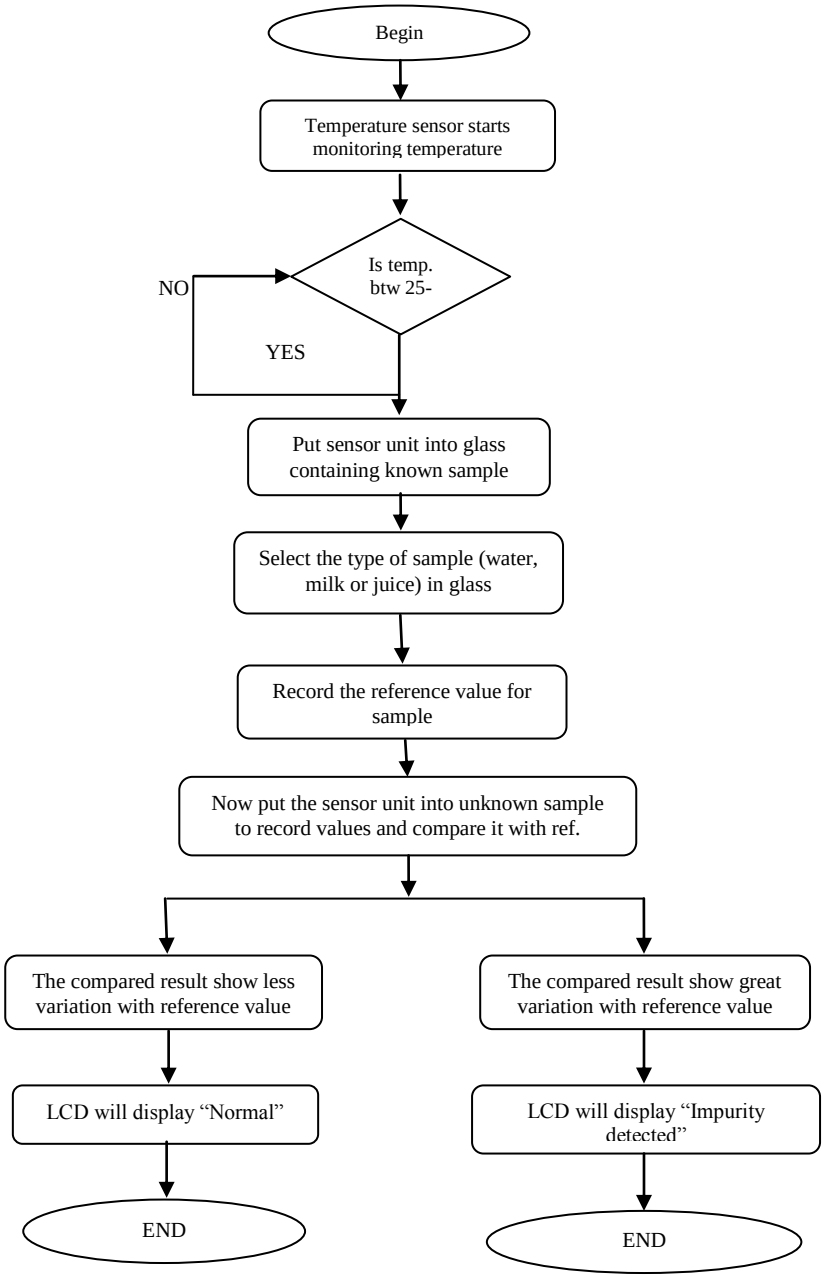

Fig.1.2. Flow Chart of the Proposed Work

4. Result and Discussion

Increase in temperature causes the decreases in viscosity and hence increase in mobility of solution. As temperature increases, the dissociation of molecules leads to increase in number of ions in the solution. All these factors lead to increase in conductivity with increase in temperature [4]. If any dissolved solids like any chemical pesticide present in the solution, then the conductivity of the solution increases due to increase in dissociation of molecules. To measure conductivity, TDS meter is used that shows the value of electrical conductivity between the two electrodes that are equally spaced from each other. TDS meter gives the value of conductivity when the meter is dipped into the solution containing pesticide. Table 1 shows the mean value of conductivity and relative percentage deviation between the pesticide containing samples and pesticide free samples of various vegetables. The statistical representation of the variation between the different samples is shown in the fig 1.4.

At the same time, when light falls on any solution and sufficient energy is provided by it to the electrons that leads to breakage of bonds of electrons from the atoms. This discharge charge carriers flows inside the solution and results into flow of current. Also, the different type of solution absorbs light at different rate. So the value of light absorbance at the receiver side will be different [18]. The light absorbance rate depends upon the color, thickness and dissolved solids present in the solution. In the present study, the light intensity absorb by different vegetable juices is monitored with or without any chemical pesticide. The variation between the values of pesticide free and pesticide containing samples is represented in the graph (fig 1.3) as well as in the tabular form (table 2).

The proposed method determines the pesticide residues in bitter gourd, tomatoes and bottle gourd samples collected from both market and agriculture farms. Five samples of each vegetable are investigated. It was found that most of the pesticide containing samples show large variation from the values gets from pesticide free samples. That large variation shows the presence of pesticide in samples and serious threat to human health. The tables(1, 2) shows that the relative percentage deviation between the value of light intensity absorb in organic sample and the pesticide containing samples and also between organic samples and market samples are more than 5%. Also, the relative percentage deviation between the pesticide containing sample and the market samples is very less. Hence, shows the presence of pesticide in both the samples.

Table 1. Shows the Mean Value of Conductivity and Relative % Deviation in Various Type of Samples

Sample type	No. of samples analyzed	Mean value* of conductivity			Relative % deviation	
		Pesticide free samples	Pesticide containing samples	Market samples	Pesticide containing samples	Market samples
Bottle gourd	4	142	157.2	154.4	10.7%	8.7%
Bitter gourd	4	176.4	121	117.2	31.4%	33.5%
Tomato	4	166	197.7	193.5	19.09%	16.56%

*Mean of the values get after investigating different number of samples.

Table 2. Shows the Value of Mean of Light Absorbance and Relative % Deviation Value in Various Types of Samples

Sample type	No. of samples analyzed	Mean value* of Light absorbance value			Relative % deviation	
		Pesticide free Samples	Pesticide containing Samples	Market sample	Pesticide containing samples	Market sample
Tomato	4	182	196.3	200	7.8%	9.89%
BitterGourd	4	136.3	146.6	147	7.5%	7.8%
BottleGourd	4	116.6	127	124	8.9%	6.34%

*Mean of the values get after investigating different number of samples.

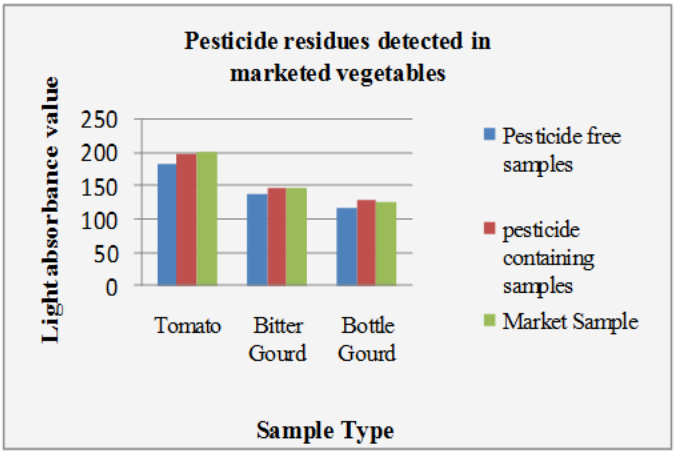

Fig.1.3. Graph Shows the Different Light Absorbance Values of Various Samples.

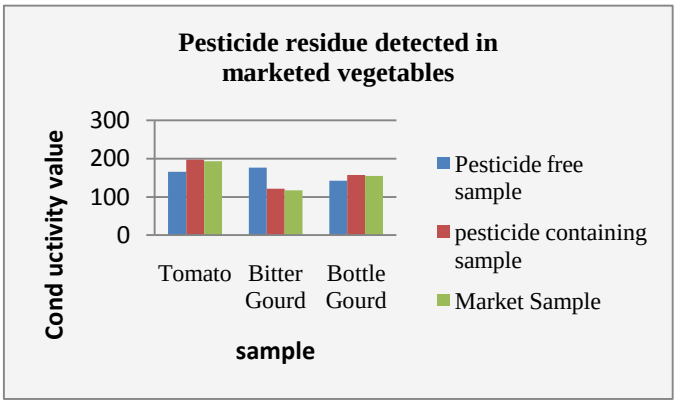

Fig.1.4. Graph Shows the Different Conductivity Values of Various Samples.

The analysis of pesticide (chloropyrifos) residue in pesticide containing vegetable samples and the results obtained were compared with the pesticide free samples. This study showed analyzed vegetable samples contains some degree of contamination. It is required that the farmers should be given a proper knowledge regarding the use of pesticide to protect them from the pesticide exposer.

5. Conclusion and Future Scope

In conclusion, to overcome the various limitations faced during the use of conventional methods, a new pesticide residue detection method is proposed. This proposed system monitor the various parameters of fruit/vegetable juice like conductivity, pH and light absorbance value of different samples for the presence of pesticide residue. After testing, the results conclude that the values of parameter are changing with the varying amount of pesticide residue in different samples. That change in value of parameters indicates the presence of impurities in the samples. The method had been successfully used for the detection of pesticide residues in vegetable samples. In future, this method can be used on various other types of vegetables and fruits and more number of chemicals can be monitored.

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Balwinder Singh has obtained his PhD from Guru Nanak Dev University, Amritsar and he has also done his Bachelor of Technology degree from National Institute of Technology, Jalandhar and Master of Technology degree from University Centre for Inst. & Microelectronics (UCIM), Panjab University, Chandigah in 2002 and 2004 respectively. He is currently serving as Sr. Engineer in Centre for Development of Advanced Computing (CDAC), Mohali and is a part of the teaching faculty. He has 10+ years of teaching experience to both undergraduate and postgraduate students. Singh has published two books and many papers in the International & National Journal and Conferences. His current interest includes Genetic algorithms, Low Power Techniques, VLSI Design & Testing, and System on Chip.

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How to cite this paper: Deepali Gupta, Balwinder Singh, Harpreet Singh,"Design and Development of Pesticide Residue Detection System using EC and pH Sensor", International Journal of Engineering and Manufacturing(IJEM), Vol.6, No.2, pp.10-17, 2016.DOI: 10.5815/ijem.2016.02.02