International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-5, March 2020

Predictive Model for Reservoir Level of Peruvannamuzhi Dam in India

Shyju. S, Lini Mathew

Abstract: Peruvannamuzhi Dam is built on the Kuttiady River at Kozhikode district, Kerala, India. The main purpose of the dam is to store water safely for irrigation and to control flood at the downstream area. Hydroelectric power plant is not associated with this Dam. At present, the basic dam operation parameters like reservoir level, rain data, and outflow rate are measured manually. There is no provision for inflow measurement. Most of the state reservoirs are almost full when heavy rainfall occurs during monsoon. The opening and closing of the gates of the dam depend only on the current water level of the reservoir. So the dam operators are forced to open suddenly all the shutters of the dam when water reaches Full Reservoir Level and this is a compensatory procedure. The sudden release of water simultaneously from different reservoirs caused flood in Kerala. This paper presents Internet of Things based automatic monitoring of different parameters for dam management and predict reservoir level after a particular period, say 2 hours. The above specified dam parameters is measured with different sensors like ultrasonic sensor and rain sensor. NodeMCU upload the measured data to cloud. Thingspeak IoT platform provide these data to user. Thingspeak provide MATLAB link and which analyze and predict reservoir level. These data and predictions are easily available to dam authorities, dam researchers, farmers and public through their mobile phone or Personal Computer. With the help of this prediction, the operator can open the shutter in an anticipatory manner. This predictive model can be used for flood control.

Keywords: Internet of Things, Dam automation, Thingspeak, Ultrasonic sensor, NodeMCU, Prediction.

I. INTRODUCTION

In India, there are more than 5200 dams and among the above 4100 are about 25 years old. Central water commission is the organization looking after the matters related to dam safety. The main purpose of the dam is to store water safely for irrigation, production of electricity, etc. The safety of dams has huge importance regarding people staying in the downstream area of the dam. When dam failure occurs, densely populated areas will be badly affected. Not only death but also huge economic loss will occur due to its impact. During monsoon, dams reach their maximum capacity. In states like Kerala, the electricity required is produced from hydroelectric power plants associated with such dam.

Revised Manuscript Received on March 30, 2020.
* Correspondence Author
Shyju. S*, Scholar, Department of Electrical Engineering, National Institute of Technical Teachers Training and Research (NITTTR), Chandigarh under Punjab University, Punjab, India.
Dr. Lini Mathew, Professor, Department of Electrical Engineering, National Institute of Technical Teachers Training and Research (NITTTR), Chandigarh, Punjab, India.

In Kerala during August 2018, heavy rainfall associated with monsoon created a severe flood. 483 people died and 14 are missing. The red alert was announced in all districts of Kerala. More than 1/6th of the population of Kerala has been badly affected by the flood. Government of India announced this severe flood as level 3 calamity. Out of 79 dams in Kerala, 35 were opened. For the first time in the history of Idukki Dam, 5 overflow gates were opened at the same time.

One of the major reason that caused flood in Kerala is the improper dam management. It is reported that there was a total failure of the water management of 79 dams in Kerala. Most of the state's reservoirs were almost full when heavy rainfall occurred in August 2018 and the sudden release of water simultaneously from different reservoirs during heavy rainfall aggravated the damage.

In August, the state received 164% of rainfall it usually gets during the period. The state had been receiving more rainfall since the beginning of monsoons. It had received 15% more rain in June and 18% more in July. A spell of extremely heavy rainfall began on August 8. The flood damages could have been reduced by 20-40% if the dams and reservoirs released the water slowly in two weeks when the rains had subsided. The state did not have an advanced warning system in place and released water from the dams only once the danger level (levels at which the dams structures can be damaged) were reached" [1][2].

So we need real-time monitoring [3][5] and prediction [4][8] of water level for preventing a dam-related disaster like a heavy flood in Kerala. If the dam official has got a clear idea about the status of water level after specified time they can manage the gate of the dam without creating flood on the downstream side of the dam.

Monitoring the dam parameters [6][7] is very important considering situations like water scarcity and excess of water. The sudden opening of gates of the dam may create floods on the downstream side of the dam. So proper predictive mechanism is essential

II. PROPOSED METHODOLOGY

This research shows the usage of sensors and updated technology to manage the water level of the dam. The block diagram representation of the proposed system is shown in Fig 1. The proposed work is based on the current need for monitoring dam parameters and with the help of these data, MATLAB based calculation will predict the status of water level after 2 hours, 4 hours or any predefined time. The operator can close or open the gate of the dam by this prediction. The proposed model provides the facility to monitor

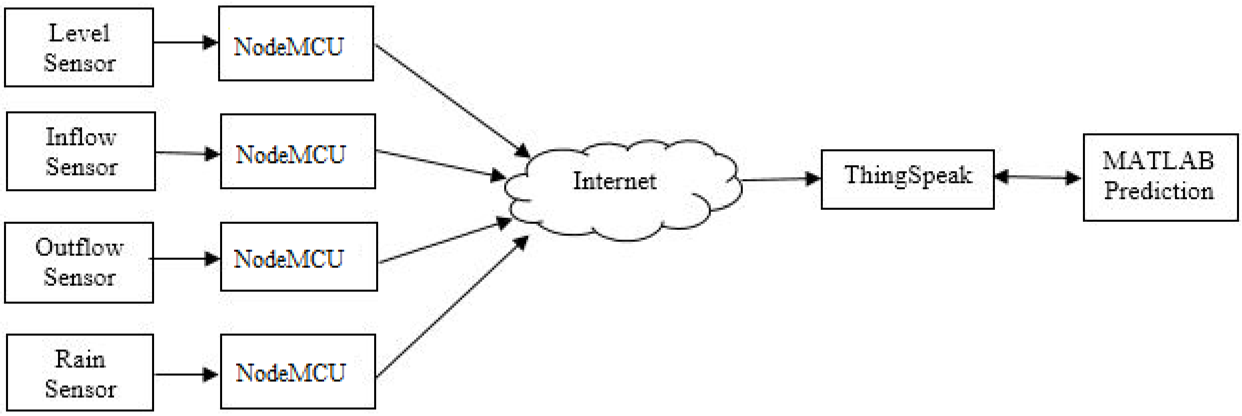

Fig.1.Block Diagram of Proposed Model

the four important parameters; viz. reservoir level, inflow rate, outflow rate and rain data. The instrumentation system consists of four sensors for detecting four input parameters. A NodeMCU upload these parameters to Thingspeak server. NodeMCU is a low cost IoT platform embedded with the processor and Wi-Fi module. Its hardware is based on ESP-12 module and included firmware, which runs on the ESP8266Wi-Fi SoC. With the help of common user name and password, anybody can access these four data from the Thingspeak. Thingspeak provides additional facility to analyze data with MATLAB. The prediction based on these acquired data is displayed on the Thingspeak automatically.

A. Level Measurement

The total catchment area of Peruvannamuzhi dam is 108.78km^2 and the Full Reservoir Level is 44.41m. Gross storage capacity of the dam is 120.52Mm^3. Fig. 2 shows the manual level measuring mechanism used in this dam. It is a calibrated rod that is capable of measuring reservoir level.

Fig.2.Manual Level Measurement

In this project, ultrasonic sensor (JSN-SR04T-2.0) is used to detect reservoir water level. Fig. 3 shows the circuit diagram of proposed automatic level measuring system. The regulator IC 7805 converts 9V DC from battery into 5V DC.

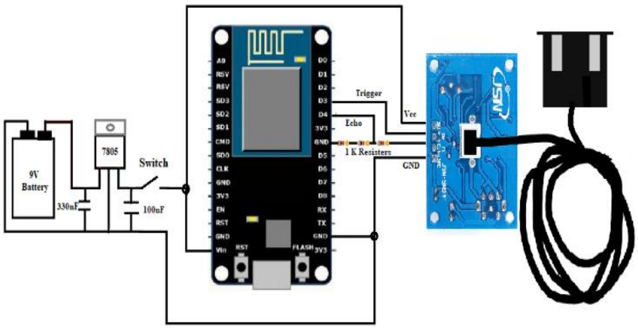

Fig.3.Schematic Diagram of Reservoir Level Measurement

This 5V acts as supply unit for both NodeMCU and ultrasonic sensor unit. Trigger pin is connected to the D3 pin of NodeMcu. Echo pin of ultrasonic sensor is connected to the D4 pin through a voltage divider circuit, because maximum input voltage received by a NodeMCU is 3.3V. NodeMCU utilizes the external Wi-Fi connectivity and push the reservoir level data into the predefined channel/field of the Thingspeak. Fig.4 shows the installation of ultrasonic sensor.

Fig.4.Ultrasonic Sensor Fixed on the Tip of the Pipe.

Fig. 5 shows the full hardware unit for reservoir level measurement. JSN-SR04T is industrial grade waterproof ultrasonic sensor with accuracy up to 2mm.

Retrieval Number: E2631039520/2020©BEIESP
DOI: 10.35940/ijitee.E2631.039520
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

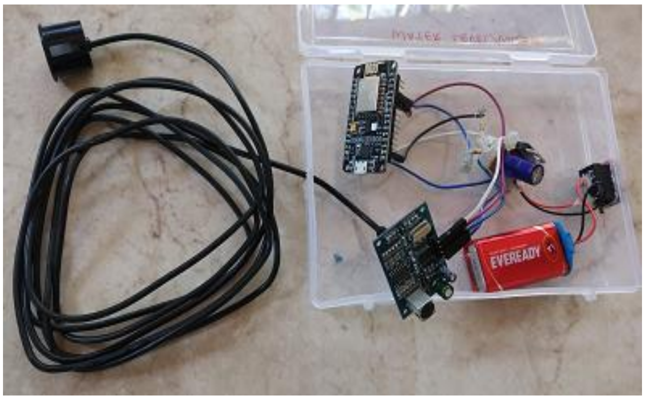

Fig.5. Hardware for Reservoir Level measurement

Fig. 6 shows the obtained reservoir level from Thingspeak, it is 40.206 m (40 meter, 20cm and 6 mm).

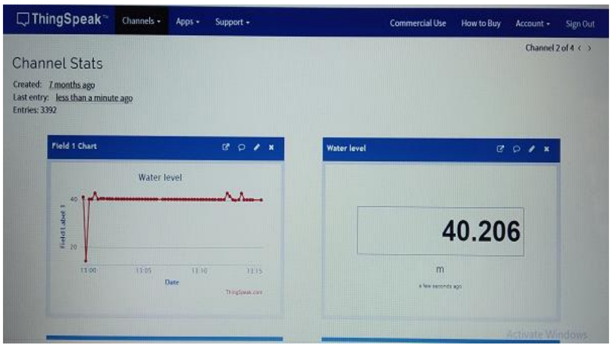

Fig.6. Reservoir Level Uploaded to the Cloud

B. Outflow Measurement

Peruvannamuzhi dam contain 4 spillways and controlled out flow with the help of 4 motor operated radial gates. Manual measurements are taken from the dial as shown in Fig. 7.

Fig.7. Manual Gate Position Measurement

Readings of the dial is from 0 to 10. When dial moves from
0 to 10 then the position of shutter is from 0 to 1.5m. Two full rotation of pointer on the dial shows 3m gate position (maximum gate position).

Ultrasonic sensor (HC-SR04) is used for detecting gate position. When motor rotates, a particular gear mechanism rotates the pointer of the dial. The link between motor and the dial mechanism is a transmission shaft. This shaft also rotates in proportional to the gate position/pointer. Fig.8 shows the hardware unit required to measure gate position

Fig. 9 shows the hardware unit attached to the rotating mechanism of the motorized shutter operating unit. At the time of installation of automatic gate position indicator, the reading on the dial is 1, it means the gate is at 15cm away from its closed position.

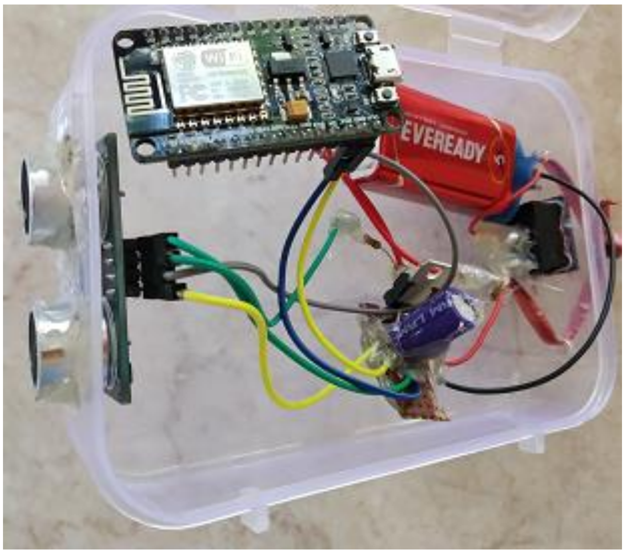

Fig.8.Hardware for Gate Position Measurement

Fig.9. Ultrasonic Sensor Module Fixed on the Rotating Unit

Discharge through the four gates has been calculated as follows,

Full Reservoir Level = 44.41m
Crest level = 38.44 m
Depth of water, H = 44.41 - 38.44 = 5.97m
Coefficient of discharge, C_d = 0.685
Acceleration due to gravity,g = 9.81m/s^2
Size of gate = 12.2m x 7.62m
Number of gates = 4

Total width of the gates, B = 4 x 12.2 = 48.8m
Discharge through gate = 2/3 x Cd x B x $\sqrt{2g}$ x $H^{3/2}$
Designed discharge Q=2/3 x 0.685 x 48.80x $\sqrt{2 \times 9.81}$ x $5.97^{3/2}$

Crest is the topmost point of the outflow section of the dam. Bottom point of the shutter indicates the crest level. Controlled out flow through the gates is possible only when the liquid level exceeds the crest level.

Fig. 10 shows the obtained Gate position from Thingspeak, it is 15cm.

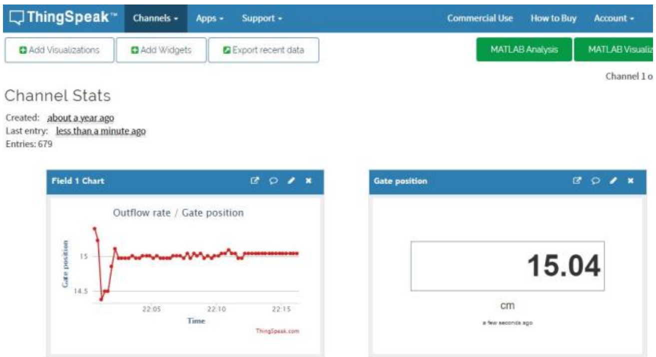

Fig.10. Gate Position Uploaded to the Cloud

Discharge through the four gates when shutter of the Dam has been raised to 15cm and can be calculated as follows,

Discharge Q = 2/3 x Cd x B x $\sqrt{2g}$ x ($H_1^{3/2}$- $H_2^{3/2}$)
H_1 = Current Reservoir level-Crest level
H_2 = H_1 - Shutter position (15cm)

C. Inflow Measurement

At present there is no facility for inflow measurement at Peruvannamuzhi dam. Commonly used mechanism for flowrate measurements in dams are rectangular notch type mechanical measurement. Due to some geographical reasons notch type measurements are not applicable here. Peruvannamuzhi dam is situated at the lower catchment area of the Kakkayam dam and is 30 km away. Water in the Peruvannamuzhi dam originates from the reservoir of the Kakkayam dam. A hydroelectric power plant is associated with the Kakkayam dam, which generates 220 MW electricity per day. Two spillways provide the controlled release of water from the dam.

Total input quantity of water at Peruvannamuzhi reservoir has been calculated from the data obtained from the Kakkayam reservoir. It is the sum of quantity of water through
spillways and penstock of Kakkayam reservoir. The shutter position determines the quantity of water through spillways. Ultrasonic sensor is used to determine the shutter position. The quantity of water flow through the penstock is a function of power generated. In the proposed model, power generated for 2 hours is readily available (Dam records) and quantity of water required has been calculated easily.

Average electricity production per day in Kakkayam Dam (24hours) = 1.5 million units
Quantity of water required to generate one unit of electricity = $0.7m^3$
Total quantity of water required to generate 1.5 million units of Electricity = $1.5 \times 10^6 \times 0.7\ m^3$ = $1050000\ m^3$
Quantity of water that reaches Peruvannamuzhi reservoir from Kakkayam dam in 24 hours =$1050000\ m^3$
Quantity of water that reaches Peruvannamuzhi reservoir from Kakkayam dam in 2 hours =$1050000/12\ m^3$ =$87500\ m^3$

D. Rain Data Measurement

The currently using manual rain sensing unit is shown in Fig. 11. It is a calibrated measuring jar.

Fig.11.Manual Rain Data Measuring Unit

The collected rain water for a period of time is poured into the measuring jar and it provides the rain data in millimeter. The schematic diagram of automatic rain sensing unit is shown in the Fig. 12. Rain sensor module consists of both the rain board and the control board. Potentiometer in the control board provides the facility to adjust the sensitivity of the device. The device consists of both analog and digital output. The range of analog pin is from 0 to 1023. It is converted into 0 to 100% and then in terms of volume for a period of time.

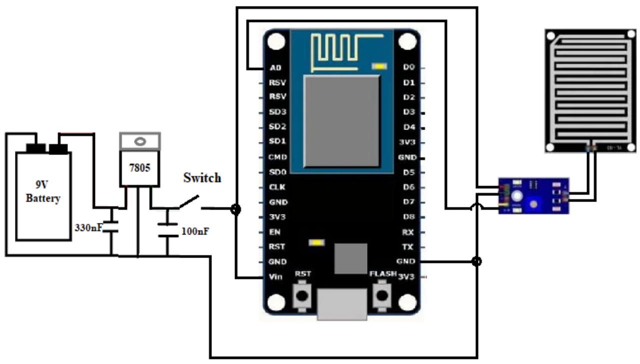

Fig.12.Schematic Diagram of Rain Measurement

The implemented calibrated hardware unit is shown in Fig.13. Rain board is kept open in the rain and the other control unit is under sealed package.Fig. 14 shows the obtained rain data in percentage from Thingspeak,it is 14%. At the time of MATLAB programming this percentage reading is converted in terms of volume.

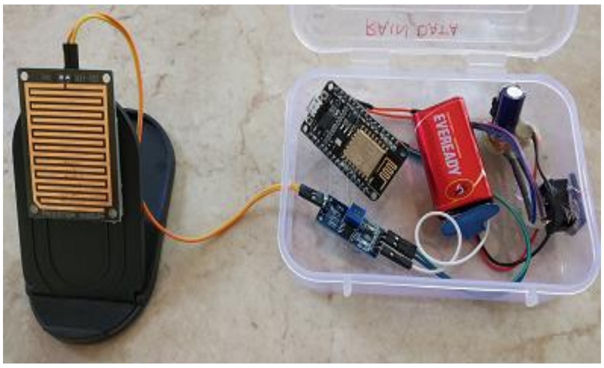

Fig.13. Hardware for Rain Measurement

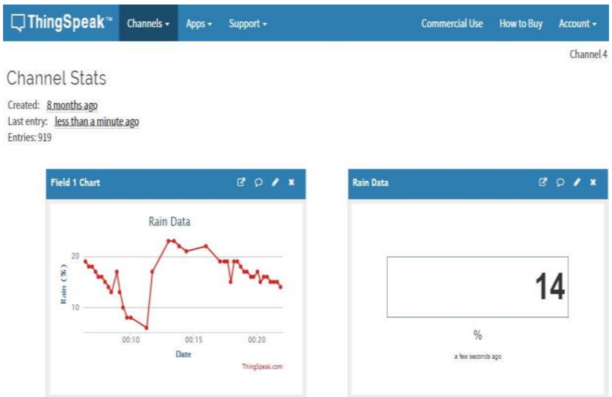

Fig.14. Rain data Uploaded to the Cloud

E. MATLAB Prediction

Fig. 15 shows the flow chart of the proposed model. The flowchart prepared shows prediction after 2 hours. Predictions can be made for any time duration by simply changing time value in the MATLAB program. Predictions are made by analyzing the four measured parameters. First step is to convert these parameters to a common dimension Here we convert it to "volume" of liquid.

As per the dam records (Rule Curve), Table 1 shows liquid level versus volume of liquid in the reservoir. These datas are readily available and used as lookup table in the MATLAB program. Ultrasonic sensor measures the present liquid level and these data are also available on the reservoir level channel of the Thingspeak. MATLAB program use these level data and with the help of lookup table, convert it in the form of equivalent volume (A).

Second ultrasonic sensor measures the gate position for outflow rate measurement from the dam. The gate position in cm is available on the Outflow rate channel of the Thingspeak. MATLAB program use these data and convert it in to equivalent volume (E) for two hours.

Third ultrasonic sensor measures the gate position in cm of the Kakkayam Dam and this data is uploaded to the Inflow rate channel of the Thingspeak. MATLAB program use this data and convert it in to equivalent volume (B) for two hours. Quantity of water flows through pen stock is already available in the MATLAB program and it also converted into equivalent volume (C) for two hours.

Rain sensor module upload rain status in 0 to 100% scale. These data available on the rain data channel of the Thingspeak. MATLAB program use these data and convert it in to equivalent volume (D) for two hours. Volume of water in the reservoir after two hours is the function of current volume of water, inflow rate, outflow rate and rain data. So volume of water in the reservoir after two hours is,

$$V = A + B + C + D - E$$

With the help of same Lookup Table 1 the MATLAB program convert this volume V into corresponding level of the reservoir. This predicted level has been uploaded to cloud and is obtained the Thingspeak as shown in Fig.16.

Table 1 Reservoir level versus volume (Dam Records)

Level (m)	Volume (Mm^3)	Level (m)	Volume (Mm^3)
26	8.128	36	50.148
27	10.748	37	57.876
28	13.696	38	64.337
29	16.596	39	73.360
30	20.418	40	81.088
31	24.634	41	90.292
32	29.332	42	100.296
33	33.995	43	109.200
34	38.595	44	118.899
35	44.340	44.41	120.52

III. RESULTS AND DISCUSSION

The proposed model is designed to update the prediction after every 5 minutes. Every 5 minutes, Thingspeak predicts and updates the status of reservoir level for 2 hours.

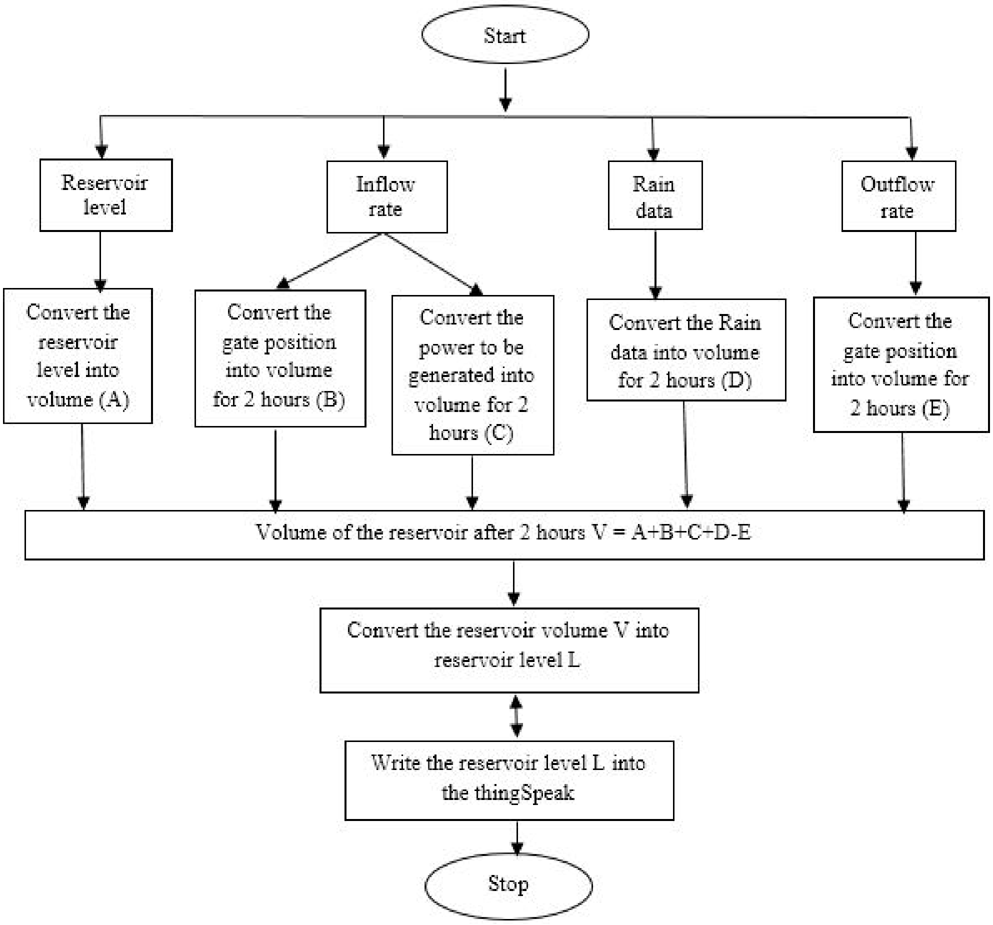

Fig.15.Flowchart of the Implementation

Observations were made on 07/01/2020 (day1) and 05/02/2020 (day2). Table 2 illustrates six predictions of reservoir level for the mentioned two days. Reservoir level predictions of day 1 is from 11.30 AM to 5.30 PM and day 2 is from 10AM to 4 PM. While making observations on day1 there was no rain fall. Due to warm weather, the loss of water by evaporation created a minute error in the predicted value.

By the end of January, dam level is fast receding due to surface evaporation and usage of water for irrigation and drinking purposes. The reservoir level started increasing during the first week of February due to the light rainfall received on the catchment area.

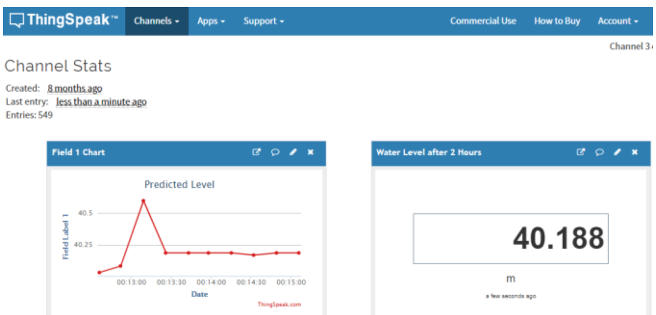

Fig.16. Predicted Level Uploaded to Cloud

Table 2 Dam Parameters and Predicted level (Result)

Time	Current Reservoir Level (m)	Inflow		Outflow Gate Position (cm)	Rain Data (%)	Predicted level After 2 hours (m)
		Gate position (cm)	Penstock (m^3)			
DAY 1 (07/01/2020)						
11.30 AM	40.206	0	87500	15	0	40.209
01.30 PM	40.205	0	87500	15	0	40.207
03.30 PM	40.204	0	87500	15	0	40.207
DAY 2 (05/02/2020)						
10.00 AM	40.173	0	87500	15	14	40.177
12.00 PM	40.177	0	87500	15	07	40.179
2.00 PM	40.179	0	87500	15	21	40.188

The overall resolution of the model is 0.001m.

The accuracy of the model can be increased by increasing the number of rain sensors at different places of the catchment area and connected together with ZigBee. 9V battery can be replaced with rechargeable battery operated with solar panel. At the time of measurement, the shutters of Kakkayam dam are in closed position. Hence gate position in cm is 0.

IV. CONCLUSION

The main purpose of Peruvnnamuzhi Dam is irrigation and flood control. The manual monitoring of different dam parameters are time consuming and inaccurate. In this paper, reservoir level can be monitored and predicted by analyzing different dam parameters. This IoT based predictive model for water management system provide real time data with high accuracy. The spillway control of dam based on this prediction is a solution for effective disaster management like flood. This system is applicable in any dam by analyzing the respective dam parameters.

REFERENCES

1. Di Zhang, Junqiang Lin, Qidong Peng, Dongsheng Wang, Tiantian Yang, Soroosh Sorooshian, Xuefei Liu, Jiangbo Zhuang, "Modeling and simulating of reservoir operation using the artificial neural network, support vector regression, deep learning algorithm" , Journal of Hydrology, Vol.565, pp.720-736, 23 August 2018.
2. Nikhil M Dhandre, M.M.Jadhav, "Dam data collection and monitoring system", International Journal of Science and Research(IJSR), Vol.5, Issue.6, pp.1787-1790, June 2016
3. Fi-John Chang, Ya-Ting Chang, "Adaptive neuro-fuzzy inference system for prediction of water level in the reservoir", Journal of Advances in Water Resources, Vol.29, pp.1-10, 15 July 2005
4. Zeyana Mohammed Abdullah Al-hadhrami, Dr.Abdul Khalique Shaikh, "A system for remote monitoring and controlling of Dams", International Journal of Programming Languages and Applications (IJPLA) Vol.7, pp.1-18, October 2017
5. Sai Sreekar Siddula, Phaneendra Babu, P.C. Jain, "Water Level Monitoring and Management of Dams using IoT", IEEE Transactions on Industrial Electronics, Vol.72, pp.606-613, 05 November 2018.
6. Niteen Mohod, "Usability of Internet of Things [IoT] For Dam Safety and Water Management", International Journal of Research in Advent Technology, Vol.5, pp.29-30, January 2017
7. Saranya. B, Sanju.S, Santhiya.Sandhiya.G, Palanivel.D, "Automatic gate control and monitoring", International Journal of Research in Electronics, Vol.3, No.3, 2016
8. Endrowednes Kuantama, Pono Mardjoko, Made Anggrecia saraswati, "Design and construction of Early flood warning system through SMS based on SIM 300C GSM Modem" , Third International Conference on Instrumentation, Communication, Information technology, and Biomedical Engineering (IEEE), Bandung, pp. 115-119, Nov 2013
9. Mrunalini Bajare, Shraddha Kawade, Manali Kamble, Apurva Deshpande, Prof.Jayant D, "Preventive maintenance system for dam using IOT and cloud", Second International Conference on Inventive Communication and Computational Technologies (IEEE), Coimbatore, India, pp. 1166-1170, April, 2018
10. Nor Anum Zuraimi Md Noar, Mahanijah Md Kamal, "The development of smart flood monitoring using ultrasonic sensor with Blynk applications", Fourth IEEE International Conference on Smart Instrumentation Measurement and Applications, Putrajaya, Malaysia November, 2017
11. S. Damodaran, G. Rajasekhar Reddy, Pranay Cheetirala, Dr.M.Lakshmi. "Hydrological model for flash flood prediction and flood level monitoring in reservoir using web server". International Journal of Pure and Applied Mathematics". Vol. 118, No. 24, pp. 1-9, May 2018.
12. S.Vandana, D Deepak Raj, B. Rushika, V. Mano Venkatesh, "Flood alert system using IOT". International Journal of Computer Science and Engineering. Vol. 6, Issue. 11, pp. 444-447, November 2018
13. Niteen Mohod, "Usability of internet of things for dam safety and water management", International Journal of Research in Advant Technology, Vol. 5,No.1,pp. 29-30,January 2017.
14. Asad Ahmed Mohammed Eltaieb, Zhang Jian Min, "Automatic water level control system", International Journal of Science and Research,Vol.4, Issue.12,pp.1505-1509, December 2015.
15. Rastko Martac, Nikola Milivojevic, Vladimir Milivojevic, Vukasin Cirovic, Dusan Barac, "Using internet of things in monitoring and management of dams in Serbia", Electronics and Energetics, Vol.29, No.3,pp.419-435, September 2016

AUTHORS PROFILE

Shyju. S, PG scholar in (Instrumentation and Control) Electrical Engineering Department at National Institute of Technical Teachers Training and Research (NITTTR), Chandigarh under Punjab University. Graduate in Applied Electronics and Instrumentation Engineering from University of Calicut in 2000 and currently working as a Lecturer in Instrumentation Engineering in Government Women's Polytechnic College, Kottakkal, Malappuram district, Kerala, India. He has sixteen years teaching experience in different institutions across Kerala. It include Vocational Higher Secondary School, Polytechnic Colleges and Engineering College. His interested area include Industrial Automation, Chemical and Industrial Process Control, Industrial Instrumentation, Biomedical Instrumentation, Virtual Instrumentation and Internet of Things.

Dr. Lini Mathew is working as Professor in Electrical Engineering Department at National Institute of Technical Teachers Training and Research (NITTTR), Chandigarh. She availed Ph.D. (Electrical Engineering) from Punjab University, Master of Engineering. (Electrical Engineering) from Punjab University, Bachelor of Engineering. (Electrical Engineering) from Kerala University. Her Research Interests include Digital Signal Processing, Soft Computing Techniques, Virtual Instrumentation, Measurement Instrumentation and Data Acquisition, Power System Stability. She had authored several International Journal papers.