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Fluvial Particle Monitoring System : A Case Study of Bagmati River

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***Abstract* — A study is done to develop fluvial particle monitoring system based on application of spectral imaging, image processing and artificial neural network. Research in this field has been initiated from 2004 at Kathmandu University.**

This research is applied to Bagmati river which is the principal river flowing and draining across Kathmandu Valley. Fluvial particles of Bagmati River were continuously monitored at 18 different strategic locations. These samples were continuously monitored in the Lab of Machine Vision at Kathmandu University in separate pre-monsoon, monsoon and post-monsoon seasons of 2011. A lab set up equipped with image processing and spectral imaging is developed to monitor the contents of fluvial particles. The set up resembles as a river path that contains upper reservoir and lower reservoir and a special transparent flow cell fabricated in between to monitor the particles instantaneously. An application is developed to characterize the particles that run on computer using Matrox imaging Library software and Mat lab 6.5 environments.

The samples were taken in standard 125 millilitre jar. It characterizes organic and inorganic according to the spectral signature of the particles trained with Artificial Neural Network. Organic particles have different signature than that of inorganic and are most distinct at 630 and 670nm wavelength. Based on these characterizing properties samples from 18 strategic locations of Baghmati rivers were characterized. Reflectance property is used to characterize particles with Perceptron neural network and hardlim as a transfer function. The result depicted that the ratio of organic to inorganic is found to be 0.1111 at upstream of Sundarijal, 0.13889 at Guyeswori and 0.16 at Chobhar according to weight basis. Chobhar is the spot with high amount of both organic and in-organic contents. According to particles count the ratio of organic to inorganic is found to be 0.02362 at upstream of Sundarijal, 0.02955 at Guyeswori and 0.034576 at Chobhar. So this result shows that this system can be applied for water particles monitoring. This system can be used to find out the socio-economic activities at different points, suitable waste-water treatment plant area, irrigation and aquatic life preservation.

***Key Words* — Artificial Neural Network, Fluvial Particles, Image Processing, Spectral Imaging.**

I. INTRODUCTION

Bagmati River is one of the main rivers that flow along the Kathmandu Valley, the capital city of Nepal. This river drains all the cultivated land of the valley. It originates from Baghdwar and is at an elevation of about 2,650m from the sea level which falls in the Shivapuri ridge and covers 32 km from Baghdwar to Chobhar of Kathmandu Valley. It has 20 different tributaries that join at 20 different junctions. Many researches has shown that the quality of river is declining by various means like high levels of faecal coli form bacteria, and sediment entering the river due to different human and natural [2]. So, the river system is rich in both biodegradable and non-biodegradable fluvial particles.

Characterizing the particles and its amount can well estimate the spots of Bagmati River where the human interference is high such as high human waste disposal area, slum squatter's area their activities and high natural disaster and flash flood area. Bagmati being a principal river of Kathmandu valley can be utilized for irrigation purpose, drinking water purpose, small scale micro hydro generating power plants, recreational use. Optimizing this resource can make the Kathmandu well, green and appropriate settlement valley [1]. For this a well technique should be explored that can fix the stations of the Bagmati River that is well suited for different purposes.

This research is done to identify the stations of Bagmati River where the fluvial particle of the Bagmati River is high or low. This technique distinguishes the particles as organic and inorganic particles. This system monitors the particles online and distinguishes as organic and in-organic particles. Optical-image processing and ANN technique is deployed using the particles signature as a teacher or characterizing property. A further application can be built-up in conjunction with this built up techniques that can separate all types of particles with river seasonal discharge. This will be useful for policy makers to identify the places for different sustainable development activities and can identify the socio-economic activities of the people of the people near by the stations, upstream and downstream of the river

II. MATERIALS AND METHODS

A. Sample Collection

Samples from Bagmati, Tinau, Roshi, Sunkoshi, Jhimruk, and Koshi rivers sources were collected to create a database that characterizes the particles of Bagmati River. Samples from these different rivers were collected to identify all kinds of particles. Sampling is one of the main important aspects of research, so for sampling a well bucket with baffles to prevent the backward flow of the particles was designed and used.

Bagmati River being the principal and rich in both organic and inorganic contents and has great value from all aspects, its management and utilization can throw solutions pertaining to water in the Kathmandu valley. So18 stations were chosen according to the tributaries junction point distance and human interference zone. The

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stations are marked from Baghdwar to Chobhar of Kathmandu valley. Baghdwar is the originating source point of the river and Chobhar is the downstream part that falls at end of the valley. As taking into account as Bagmati River source for drinking, cultivating, recreational and many more. The samples collected were bought to Machine Vision Lab of Kathmandu University in standard 125ml jar to monitor.

B. Instrument Description

To capture the image high resolution charge coupled device (CCD) camera Sony XCHR-70, Verispec® liquid crystal tunable filter and Nikon AF micro Nikor Lens of 105 mm were used. Ultraviolet, Visible and Near-infrared (UV/VIS /NIR) light sources were used to illuminate and distinguish the particles at certain wavelength. Besides a monitoring system is developed that is facilitated with computer with METEOR II hardware, Matrox imaging library(MIL) software and MATLAB 6.5.

C. Monitoring System

A monitoring set-up is fabricated that represents the river model, it consists of upper reservoir and lower reservoir representing upstream and downstream. A long hollow transparent pipe represents the path of the river. A well designed transparent flow cell is fabricated in between the pipe to capture and monitor the fluvial particles instantly. To capture the image an image acquisition table is fabricated. The acquisition table is enclosed by black box and a flexible camera holding stand is designed in such a way that the camera piece can be adjusted in any space point of the dark fabricated box. A flexible stand is installed to fix the transparent flow cell or specimen tray to capture image.

Figure 1 shows the monitoring system that categorizes particles as organic and inorganic. CCD camera and light sources is coupled with computer facilitated with Matrox Imaging Library (MIL) and application of ANN developed in MATLAB environment. This application categorizes the particles as organic and inorganic. Camera captures the fluvial particles image from flow cell instantaneously and the ANN application that is developed processes the captured and distinguishes the particles.

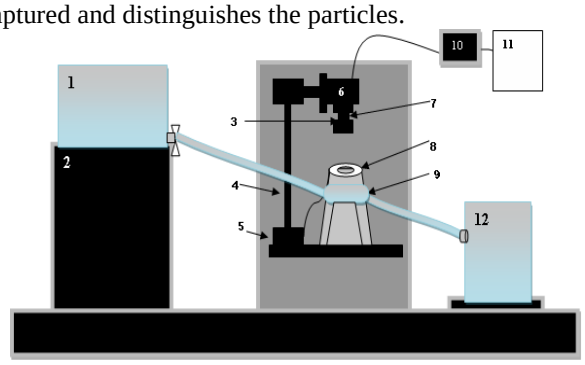

Fig.1. Schematic diagram of particles monitoring set-up

1. Upper Resevoir Tank
2. Stand for Upper Tank
3. Filter
4. Camera Stand
5. Lightsource guide
6. Camera
7. Lens
8. Lightsource
9. Transparent Flow cell
10. Camera Adapter
11. Computer
12. Lower Reservoir

D. Image Processing

Image processing is one of the important applications that can be utilized to identify the particles characteristics [7]. So to process the image first the identified particles from the reflectance at 630nm and 670nm wavelength were captured. These captured images of the particles in turn are processed to stack images to determine the gray value of the organic and inorganic particles. The gray value of the particles was determined by taking a sing image as a reference. First a Centre of Gravity (CG) of the particles was determined to create a datasets for neural network training. A fixed classifier of 9x9x42 was used to allow each image coincide with CG. 1x42 sized matrix sizes were obtained for individual dataset as an input for network. A monitoring set-up is fabricated that consists of upper reservoir and lower reservoir representing upstream and downstream. A long hollow transparent pipe represents the path of the river. A well designed transparent flow cell is fabricated in between the pipe to capture image of particles flowing.

E. Artificial Neural Network

The size determined by image processing is utilized as a datasets for the neural network training. The datasets were created from every samples collected. These datasets have an exact value of 1x42 size and is trained for 30 matrixes for organic and inorganic particles. Perceptron network with Hardlim as a transfer function is deployed to create ANN model. 42 rows with 60 columns for organic and inorganic were used as input data for the model to be created. This network was trained for each sample tested and validated with the random data. This network clearly distinguished particles as organic (O) 1 and inorganic (IO) 0. Later on the samples of 18 different strategic locations are fed to the model to distinguish the particles. This gray value of the particles and reflectance are the major features to distinguish the particles.

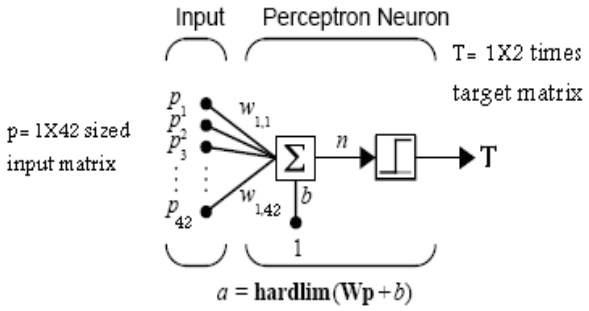

Fig.2. showing the Perceptron network with target value for each type of input sample.

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III. RESULT AND DISCUSSION

A. Image Processing

To make the processing easy a slice of image of 630nm and 670nm wavelength are taken into account. Database of 40x40 pixel images are cropped and its background color is set as white. Their histograms are plotted and filtering is done for analysis. This result gave the exact size to determine the gray value. An exact average gray value was determined. Center of Gravity is determined to find the size of classifier. Processed image of particles are shown in figure 3. Sobel method was performed, which in turn 9x9x42 classifier is developed to determine the average gray value.

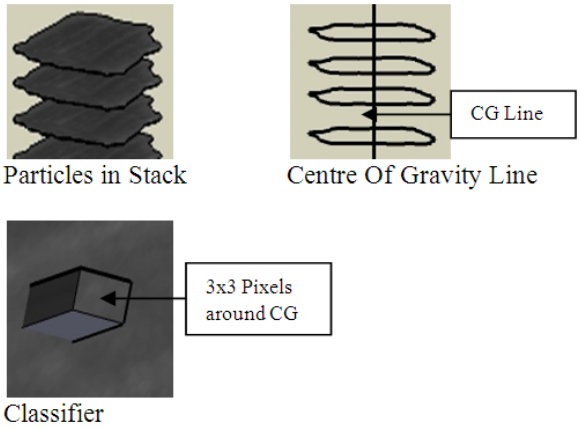


Fig.3. Image processing of a stack image

B. Particles Reflectance

Nature has given unique features to every particle, so every particle has its own spectral signature. But particles of same category have similar kinds of pattern in their spectral characteristic. Organic and inorganic particles have different characteristics [9]. This research utilizes the spectral signature of particles to distinguish organic and inorganic particles. These particles are easily identified in 630nm and 670nm wavelength. The particles reflectance characteristics at the different wavelength are shown in Figure 4 and 5.

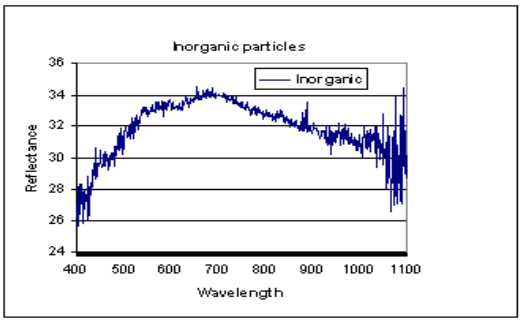
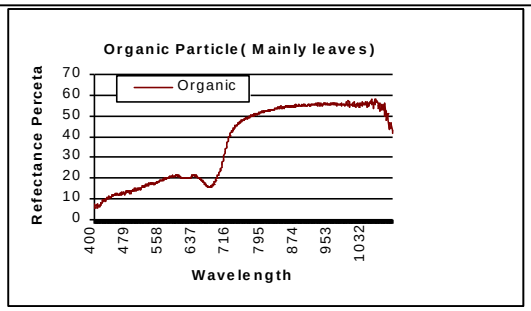


Fig.4. Reflectance of inorganic particles



(b)

Fig.5. Reflectance of organic particles

C. Artificial Neural Network

Networks with neurons acts as brain to distinguish the particles as organic and inorganic. A Perceptron model with hardlim as a transfer function is designed to distinguish the particles. These networks are trained validated and tested with the gray value of the particles at 630nm and 670nm wavelength. . It recognizes particles reflectance and gray value that it has captured and distinguishes particles as organic and inorganic. The particles training were completed with an error tolerance of $10e^{-5}$ giving a target at 24 epochs. The network was simulated with 125ml of mixture. The performance test is shown in figure 6.

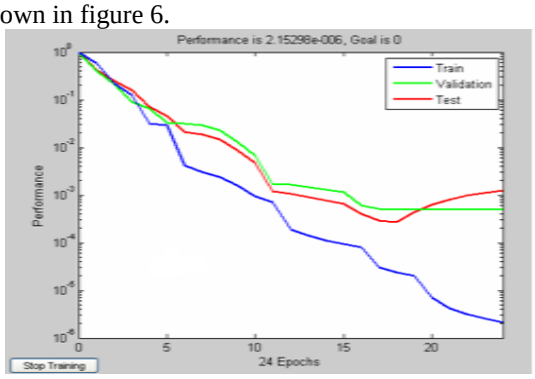


Fig.6. Performance of ANN

D. Bagmati River Fluvial Particles

The network was tested for all 18 spots of Bagmati River. It was found that the inorganic particles are highly available and the content is sand. The application developed in MIL displays the count of the particles and the result for 125ml samples of 18 spots of Bagmati showed that spot no 1 content 254 inorganic particles and 6 organic particles whereas in last spot 18 content 2950 inorganic and 102 organic particles. The organic content are less in count and it is increasing slowly in every spot. The average ratio of the organic and inorganic particles is 0.136. So the inorganic particles are approximately eight times greater than organic particles. Figure 7 shows the exact particles count by MIL application at 18 different strategic locations of Bagmati River.

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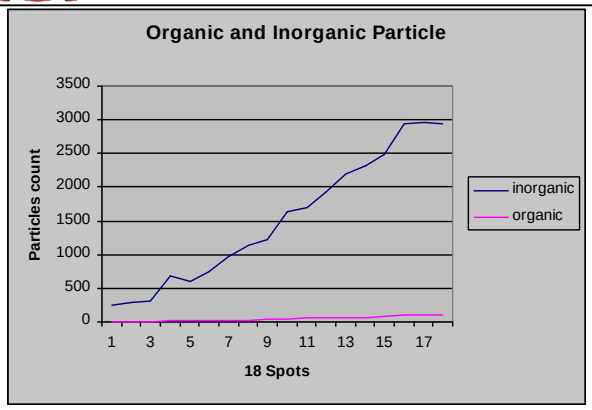

Fig.7. Particles count in 18 different stations of Bagmati River

IV. CONCLUSION

Bagmati River is polluted by various means, these all are due to human interference. It is found that organic particles are in high amount then other rivers. It is rich in both organic and inorganic content. It flows along Kathmandu Valley, this technology can be carried out in depth that can well drain and fed the valley dwellers. This system can categorize the particles and can be further carried out to identify specific particles content. A deep understanding in the fluvial particles can give a significant outlet to the society, country and for the whole world. It can be seen that spectral imaging has variety of benefits in maintaining the performance, productivity and precision of work. This part of work is a justification of this system. This system is important for water quality monitoring; drinking water policy maker to determine the proper spot for irrigation, hydro energy generation. This system can be extended to hydro vision; A new way to visualize the quality of water through vision. This system is based upon ANN, optical and spectral imaging and can play an important role to every aspect for quality assurance.

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