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Stream water quality and the catchment diversity of an Indo-Burma hotspot region of Mizoram, India

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Abstract

The present study aims to provide pollution status and the extent of disturbance made by the anthropogenic activities in the study area located in the Mizoram University. Different physico-chemical parameters of water, soil and Important Value Index (IVI) of vegetationwere analysed in this study. In the water quality analysis, the pH value 6.49±0.03in winter season at Site II is lesser than the permissible limit set by the World Health Organisation (WHO) and Bureau of Indian Standard (BIS-10500). The soils pH value which ranges from a maximum of 4.43±0.04 in rainy season at Site I and a minimum of 4±0.46 at Site III in winter seasonwere also slightly acidic which may due to high litter fall and its decomposition. In the vegetation analysis, 12 different tree species of 9 families were found and Schima wallichi got first rank with the highest IVI value followed by Phoebe lanceolata and Toona ciliata respectively. The overall analyses of different aspects with different parameters is barely done in this particular area which serves as one of the important source of fresh water and also its catchment areas provides a place for some wild animals.

Keywords: Anthropogenic, pollution, vegetation, soil, water, pH, DO, BOD.

Introduction

The increasing anthropogenic activity of the present era is polluting the fresh water source with many toxic elements. With the increasing population, the need of the freshwater is also increasing. Indo-Burma hotspot is one of the biodiversity hotspot areashaving wide ranges of ecosystems. It includes some part of eastern India, southern China, Myanmar, Thailand, Vietnam, Lao PDR and non-marine part of Cambodia. The study area acts as important source of fresh water and also its catchment areas provides many forest product. Since water quality and human health are closely related, water analysis before usage is of prime importance[1].The catchment area of the stream has a significant role in the water purification process. The soil of the catchment area have a water cleaning mechanism, add minerals and which also supports the plants that provide us with many useful products. Soil degradation from various inorganic and organic contaminants, is not only an ecological risk, but simultaneously it is also a socio-economic issue, such soil become poor in physico-chemical properties, susceptible to erosion, loss of productivity, sustainability and diminished food chain quality[2]. Soil acts as ahome for many living organisms whichin turnhelps the soil to increase fertility for the sustenance of life. Many waste products and chemical pesticides are destroyed by soil microorganisms also. A vegetation community population is characterized by its species diversity, growth forms and structure, dominance, successional trends, etc. To study the details of these aspects of any community these are taken into consideration as number of parameters. These are then used to express the characteristics of a community.

Physico-chemical parameters of water, soil and vegetation indices analysis is an important tool where there is a huge anthropogenic activity. For abatement of the pollution and anthropogenic activities cause by different factors. As a result, analysis of different parameters of different aspects is very much needed. The present study of physico-chemical analysis of water, soil and vegetation analysis is useful in terms Environmental Impact Assessment as well.

Material and Methods

Description of the study area and study site: The state of Mizoram lies in the coordinate of 21°56'N to 24°31'N latitude and 92°16'E to 93°26'E longitude, which is in the north east India. The state has a land area of 21,081 sq.km. Its capital is Aizawl and comes under the Indo-Burma hotspot region of north east India[3,4] (850 meters above sea level). It is surrounded by the state of Assam and Manipur on the north, Chinhills and Arakan hills or Myanmar on the south and on the west by Chittagong hill tracts of Bangladesh and Tripura. The climatic condition of the state is mild.In summer, the temperature ranges from a maximum 29°C to a minimum 20°C and in winter, it ranges to a minimum of 7°C to a maximum 21°C in winter. The average annual rainfall is2540 mm. The forest vegetation falls under three major categories i.e., tropical wet evergreen forest, tropical semi-evergreen forest and sub-tropical pine forest[5].

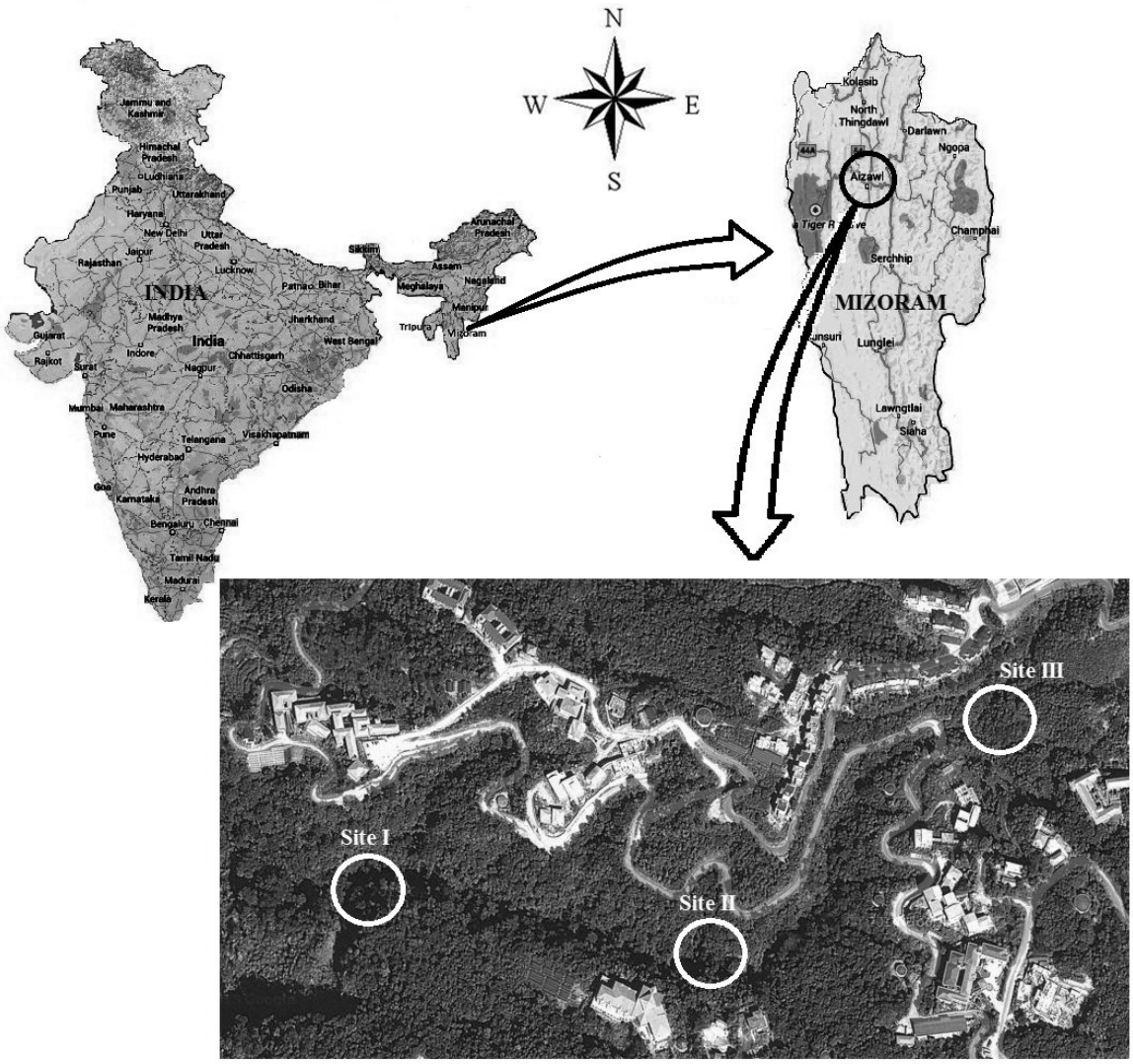

Figure-1
Map showing study area and the study sites at Mizoram, India.

The study area i.e. the stream and the catchment areais located in the Mizoram University, Tanhril,which is in the western part of Aizawl. The stream is divided into three study sites i.e. Site I, Site II and Site III (figure-1). The samplings were done seasonally from August (2013) to may (2014).

Sampling and analysis of water: Water samples were collected from different study sites at different seasons and immediately brought to the laboratory for analysis of various water quality parameters. Wide mouth bottles were used to collect samples. The analysis methods outlined in the 'Standard Methods for the examination of water and Wastewater' were used for the analysis of different water parameters[6]. Theresults were compared using WHO and BIS-10500 standard[7,8]. Tag/Labels for each batch and samples are given for easy identification. Samples were analysed immediately within 1-6 hours of collection for analysis like Temperature, pH, Acidity, Alkalinity, and Dissolved Oxygen (DO) within 24 hours except for Biological Oxygen Demand (BOD), which takes 5 day for incubation. Temperature was measured using Digital thermometer, pH by digital electronic pH meter, Acidity and alkalinity by potentiometric titration method and Dissolved Oxygen and Biological Oxygen Demands by Winkler's Method.

Sampling and analysis of soil: Soil samples were collected randomly from each site randomly with three replicate. The ground surface was first cleared of the fallen leaves and any unwanted materials. The soil was dug up to 5 cm (approximately) and the samples were collected. The soil samples were then kept in polythene bags in air tight conditions for further processing. The samples were then oven dried and sieved with 90 µm sieved. Samples were analysed in the laboratory immediately after the collection. Parameters including Temperature, pH, Soil Organic Carbon, Soil Water Holding Capacity and Soil moisture were analysed.

Temperature was measured using digital soil thermometer, pH by digital pH meter, Soil Organic Carbon by titrimetric method, Soil Water Holding Capacity and Soil moisture by gravimetric method.

Sampling and analysis of vegetation: Stratified random sampling and quadrate approach was followed for carrying out analysis of the vegetation. The size of quadrate for the trees was determined as 10m×10m. In each quadrate, diameter at breast height (DBH) of each tree were measured along with their occurrence, the number of species were also recorded. The Important Value Index (IVI) has been used to determine the dominance and ecological succession ofthe species. The method implies quantitative parameters such as abundance, frequency and basal cover of trees are determined by relative frequency, relative density and relative dominance. The analysis of important vegetation quantitative parameters such as, frequency, density and abundance of tree species were also determined[9].

Results and Discussion

Water: Six physico-chemical parameters were analysed and the result is shown in Table-1.The pH values were ranging between a maximum of 8.5±0.17 in summer season at Site III and a minimum of6.49±0.03 in winter season at Site II which is lesser than the permissible limit set by WHO and BIS i.e. 6.5 to 8.5.The mean pH values were 7.53±0.01 in rainy season at Site I, 6.65±0.03 in rainy season at Site II and 7.15±0.03 in rainy season in at Site III; 6.9±0.26 in winter season in at Site I and 7.05±0.02 in winter season at Site III; 7.05±0.10 in summer season at Site I and 7.33±0.15 in summer season at Site II (Table-1). The complex relationships of cation and anion concentrations, various ions including inorganic and organic, temperature and various environmental conditions, pH value of water regularly fluctuates. The pH of waters also influences the chemical and biochemical reactions. pH also varies usually often due to several factors such as interaction with suspended matter, polluting material, decays etc.

The temperature of is one important ecological and physical factors which have profound influence on the abiotic and biotic components of the environment[10]. The temperature of water is directly related with ambient air temperature of different seasons. It is influence by climatic factors, but influence also can be made by anthropogenic activities. The maximum value of temperature was measured 20±0.43 (°C)in summer season at Site I and the lowest were also obtained 16.7±0.26 (°C) in winter season at Site II. The mean temperature values were 19.8 ±0.30 in rainy season at Site I, 18.9±0.20 (°C) in rainy season at Site II and 18.7±0.34 (°C) in rainy season at Site III; 17±1.15 (°C) in winter season at Site I and 17.4±0.26 in winter season at Site III; 19.5±0.26 in summer season at Site II and 19.3±0.36 in summer season at Site III (Table-1). There is no permissible limit value set for the temperature. The temperature of the water bodies also affects the other parameter such as pH and DO.

The acid neutralizing capacity of water is known as alkalinity. The value of alkalinity in the study sites ranges from a maximum of 64±9.64 (mg/L) in rainy season at Site Iand a minimum of31±1.73 (mg/L) in summer season at Site II.The mean alkalinity values were 48±7.93(mg/L) in rainy season at Site II and 46±6.08 (mg/L) in rainy season at Site III; 62±5.56 (mg/L) in winter season at Site I, 60±2.00(mg/L) in winter season at Site II and 56±7.00(mg/L) in winter season at Site III; 43±3.46 (mg/L) in summer season at Site I and 35±4.35 (mg/L) summer season at Site III (Table-1). The ranges indicate that the water may present a few amounts base such as carbonates. Therefore the sample is within the limits as prescribed by WHO and BIS i.e. 200-600 (mg/L) and 200 (mg/L) respectively. Water with low alkalinity having a pH range of 6.3 to 7.3 are low in production and support phytoplankton which have low acid and low alkaline adaptation.

The Acidity ranges from a maximum of 28±5.29 (mg/L) in winter season at Site I and minimum of 4±2.64 (mg/L) rainy season at Site II. The mean acidity values were 8±1.73 (mg/L) rainy season at Site I and 8±2.64 (mg/L) in rainy season at Site III; 14±5.29 (mg/L) in winter season at Site II and 10±2.64 (mg/L) in winter season at Site III; 18±2.64 (mg/L) in summer season at Site I, 23±2.64 (mg/L) in summer season at Site II and 14±1.00 (mg/L)in summer season at Site III (Table-1). Acidity of water refers to the amount of acids bases present. There have been no particular limit for acidity and can be expresses in terms of $CaCO_3$. Highly acidic water must be avoided and could be dangerous. Acidity has been not desirable in municipal water system because it tends to increase corrosion.

Table-1
Water data (mean and standard deviation) for different seasons of different study sites

	Rainy season			Winter season			Summer season		
Parameters	**Site I**	**Site II**	**Site III**	**Site I**	**Site II**	**Site III**	**Site I**	**Site II**	**Site III**
pH	7.53± 0.01	6.65± 0.03	7.15± 0.03	6.9± 0.26	6.49± 0.03	7.05± 0.02	7.05± 0.10	7.33± 0.15	8.5±0.17
Temperature (°C)	19.8± 0.30	18.9± 0.20	18.7±0.34	17±1.15	16.7±0.26	17.4±0.26	20±0.43	19.5±0.26	19.3±0.36
Alkalinity (mg/L)	64±9.64	48±7.93	46±6.08	62±5.56	60±2.00	56±7.00	43±3.46	31±1.73	35±4.35
Acidity (mg/L)	8±1.73	4±2.64	8±2.64	28±5.29	14±5.29	10±2.64	18±2.64	23±2.64	14±1.00
DO (mg/L)	6.3±0.43	6.2±0.26	6.8±0.20	6.7±0.36	6.5±0.30	6.9±0.36	7±1.00	6.5±0.26	6.6±0.23
BOD (mg/L)	2.3±0.28	2.4±0.26	2.6±0.26	2.4±0.26	2.3±0.43	2.6±0.45	2.8±0.17	2.4±0.17	2.3±0.05

DO is one of the important parameters which plays a significant role for the survival of aquatic living organism.High pollution levels of waters is indicated by low DO concentration (<3 mg/L) in fresh water aquatic systems and cause negative effects on life in this systems[11]. The DO ranges between a maximum of 7±1.00 (mg/L) in summer season at Site I and minimum of 6.2±0.26 (mg/L)in rainy season at Site II. The mean DO values were 6.3±0.43 (mg/L) in rainy season at Site I and 6.8±0.20 (mg/L) in rainy season at Site III; 6.7±0.36 (mg/L)in winter season at Site I, 6.5±0.30 (mg/L) in winter season at Site II and 6.9±0.36 (mg/L) in winter season at Site III; 6.5±0.26 (mg/L) in summer season at Site II and 6.6±0.23 (mg/L) in summer season at Site III (table-1). It is one of the most important parameters of water quality which reflects the various processes of physical and biological in water. The higher Dissolved oxygen contain may be due to luxuriant growth of algae and aquatic plants resulting to higher photosynthetic rate as a result of increased temperature[12]and constant aeration[13].

BOD is the most important parameter of water quality. It indicates the limit of organism survival in the water. The BOD ranges from a maximum of 2.8±0.17 (mg/L) in summer seasonat Site I and minimum of 2.3±0.28 (mg/L), 2.3±0.43 (mg/L) and 2.3±0.05 (mg/L) in rainy, winter and summer seasonat Site I, Site II and Site III of respectively. The mean BOD values were 2.4±0.26 (mg/L) in rainy season at Site II and 2.6±0.26 (mg/L) in rainy season at Site III; 2.4±0.26 (mg/L) in winter season at Site I and 2.6±0.45 (mg/L) in winter season at Site III; 2.4±0.17 (mg/L) in summer season at Site II (Table-1). The enormous growth of aquatic plants may leads to high BOD of the site. High value of BOD during rainy season might be due to organic loads along the runoff from the catchment area of the lake[14]. Permissible limit set by WHO is 6 mg/L.

Soil: Five physico-chemical parameters of soil were analysed and the result is shown in Table-2. pH of a soil indicates its acidity and alkalinity. It is known to be related to the availability of micro and macronutrient for plants[15]. It ranges from a maximum of 4.43±0.04 in rainy seasonat Site I and a minimum of 4±0.46 at Site III in winter season. The mean pH values were 4.2±0.15 in rainy season in Site II and 4.15±0.05 in rainy season in Site III; 4.03±0.17 in winter season in Site I and 4.12±0.04 in winter season in Site II; 4.18±0.02 in summer season in Site I, 4.11±0.01 in summer season in Site II and 4.04±0.03 in summer season at Site III (table-2). The pH value is slightly lowerin winter and summer season. The pH is slightly acidic in all the sites. High rate of litter decomposition leads to soil pH more acidic in top-soil during post-monsoon season[16].

Temperature is one of the important parameter of soil. It plays an important role in the decomposition of soil organic content. Temperature governs to a large extend the biological species present and their rates of activities[17].It also depends on the different seasons. Temperature ranges from a maximum of 19.4±0.30(°C) in summer season and 19.4±0.05 (°C) in summer season at Site I and III respectively and a minimum of 16.7±0.50 (°C) in winter season at Site II. The mean temperature values were 18.8±0.10 (°C) at Site I in rainy season, 18.6±0.20 (°C) in rainy season at Site II and 19.1±0.37 (°C) in rainy season at Site III; 16.8±0.30 (°C) in winter season at Site I and 17.1°C±0.20 in winter season at Site III; 18.9°C±0.11 in summer season at Site II (Table-2).

Soil organic carbon is directly transferred from the plant and other dead and decay organisms in the surrounding which after decomposed absorbed through soil pores. Organic carbon ranges from a maximum of 2.57±0.13 (%) in rainy seasonat Site II and a minimum of 1.4±0.30 (%) in winter season at Site I. The mean organic carbon values were 2.31±0.26 (%) in rainy season at Site I and 2.19±0.07 (%) in rainy season at Site III; 1.8±0.17 (%) in winter season at Site II and 1.5±0.26 (%) in winter season at Site III; 1.23±0.14 (%) in summer season at Site I, 1.42±0.33 (%) in summer season at Site II and 1.35±0.07 (%) in summer season at Site III (Table-2). Soil organic carbon is taken out of the atmosphere by the plant photosynthesis about 60 gt annually is respired or oxidised from soil[18].

Table-2
Soil data (mean and standard deviation) for different seasons of different study sites

	Rainy season			Winter season			Summer season		
Parameters	**Site I**	**Site II**	**Site III**	**Site I**	**Site II**	**Site III**	**Site I**	**Site II**	**Site III**
pH	4.43± 0.04	4.2±0.15	4.15±0.05	4.03±0.17	4.12±0.04	4±0.46	4.18±0.02	4.11±0.01	4.04±0.03
Temperature (°C)	18.8± 0.10	18.6± 0.20	19.1± 0.37	16.8± 0.30	16.7± 0.50	17.1± 0.20	19.4± 0.30	18.9± 0.11	19.4± 0.05]\
organic carbon (%)	2.31± 0.26	2.57± 0.13	2.19± 0.07	1.4± 0.30	1.8± 0.17	1.5± 0.26	1.23± 0.14	1.42± 0.33	1.35± 0.07
water holding capacity (%)	32.6± 0.51	37.7± 1.57	57.44± 6.28	63.76± 5.69	52.87± 6.54	68.84± 6.96	53.22± 4.32	56.84± 3.32	58.88± 0.72
Soil Moisture Content (%)	18.2± 1.99	10.13± 1.07	13.25± 1.09	26.9± 2.17	12.86± 2.02	20.91± 0.69	32.6± 1.22	29.19± 2.38	45.56± 1.92

Water holding capacity is an important physical property of soil. Physical condition of a soil quality can be known with the determination of soil water holding capacity. Water holding capacity ranges froma maximum of 68.84±6.96 (%) in winter seasonat Site III and a minimum of 32.6±0.51 (%) in rainy season at Site I. The mean water holding capacity values were 37.7±1.57 (%) in rainy season at Site II and 57.44±6.28 (%) in rainy season at Site III; 63.76±5.69 (%) in winter season at Site I and 52.87±6.54 (%) in winter season at Site II; 53.22±4.32 (%) in summer season at Site I, 56.84±3.32 (%) in summer season at Site II and 58.88±0.72 (%) in summer season at Site III (table-2).

Soil moisture ranges from a maximum of 45.56±1.92(%) in summer seasonat Site III and a minimum of 10.13±1.07 (%) in rainy season at Site II. The mean soil moisture values were 18.2±1.99 (%) in rainy season at Site I and 13.25±1.09 (%) in rainy season at Site III; 26.9±2.17 (%) in winter season at Site I, 12.86±2.02 (%) in winter season at Site II and 20.91±0.69 (%) in winter season at Site III; 32.6±1.22 (%)in summer season at Site I and 29.19±2.38 (%) in summer season at Site II (Table-2). Soil moisture content is commonly increase by organic matter present in the soil[19].

Vegetation: From the study, a total of 12 different tree species of 9 familieswhich includes Mimosaceae, Fagaceae, Theaceae, Moraceae, Fabaceae, Meliaceae, Verbenaceae, Myrtaceae and Lauraceae were found. Among the species found *Schima wallichi* of Theaceae family got first rank with the highestIVI value of 69.84 followed by *Phoebe lanceolata* and *Toona ciliata* of Lauraceaeand Meliaceaefamilies with IVI value of 41.78 and 39.45 respectively. The recorded 12 different trees species with their IVI values in the catchment areas were tabulated in table-3. The present study revealed that *Schima wallichi* was the dominating species found in the study area. The co-dominating species such as *Phoebe lanceolata* and *Toona ciliata* were grown luxuriantly in all the three quadrats as a result the remaining species including *Castanopsis indica* having least IVI value were found in few individuals. This may be due to the competition for food and space among the different species. Also the dominating species with their spread canopies unable the sunlight to penetrate to the lower growth ground which hampered their growth.

Conclusion

The vegetationanalysis showsthe rich diversity of trees as some part of the study Site Is undisturbed. Soil is slightly acidic in all the study sites due to excess litter fall decomposition. In the water quality analysis, the pH in winter season at Site II is lesser than the permissible limit set by WHO and BIS-10500. Significant variation can be observed from the finding in the different parameters of water, soil and vegetation. This result may serve as a pilot study for further investigation of water pollution in this stream. Further periodical study on other more physicochemical and biochemical parameter test of the water and soil along with vegetation analysis will provide better knowledge for the abatement of the environmental pollution around the streams. It will also make an important contribution to the improvement of surroundings of the Mizoram University. It can be concluded that the study Site is safe without any form of treatment to some extend and could be considered acceptable.

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Table-3
Vegetation data for different seasons of different study sites

Species	Family	Local Name	Relative Frequency	Relative Density	Relative Dominance	IVI	Rank
Albiziaprocera	Mimosaceae	Kangtek	10	8.88	4.69	23.58	5
Albiziachinensis	Mimosaceae	Vang	10	8.88	5.28	24.17	4
Castanopsistribuloides	Fagaceae	Thingsia	10	8.88	2.77	21.66	6
Schimawallichi	Theaceae	Khiang	10	17.77	42.06	69.84	1
Ficussemicondata	Moraceae	Theitit	10	8.88	2.53	21.42	7
Castanopsisindica	Fagaceae	Sehawr	3.33	2.22	0.66	6.21	12
Derris robusta	Fabaceae	Thingkha	10	6.66	3.06	19.73	8
Toonaciliata	Meliaceae	Teipui	10	15.55	13.90	39.45	3
Vitexpeduncularis	Verbenaceae	Thingkhawilu	6.66	4.44	1.50	12.61	10
Callicarpaarborea	Verbenaceae	Hnahkiah	3.33	2.22	0.98	6.54	11
Syzygiumcumini	Myrtaceae	Lenhmui	6.66	4.44	1.84	12.95	9
Phoebe lanceolata	Lauraceae	Bulfek	10	11.11	20.67	41.78	2

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