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USE OF ATOMIC ABSORPTION SPECTROPHOTOMETRY IN DETERMINATION OF TRACE ELEMENTS (Cr, Cu, Fe, Ca and Mg) IN DRINKING WATER

Reviewed

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Abstract: This paper discuss basically about the detection and assessment of trace elements like Cromium, Copper, Iron, Calcium and magnesium in drinking water using atomic absorption spectrophotometry. Trace element analysis has a significant global role in health care, protection of the environment, illegal substance regulations and monitoring of waste materials as well as many other concerns. Now regulations and public concerns have greatly enriched the science of trace analytical measurements.

Key words: Atomic Absorption spectrophotometry, trace elements, drinking water.

Introduction

The atomic absorption spectrophotometry analysis is based on the principle of atomic absorption spectroscopy (AAS) and it is very useful to detect the metal ion concentration present in drinking water samples. Analysis of trace metals in water is very important as trace metal in water plays a crucial role as majority of metals act as essential nutrients at low concentration but excess levels can have harmful consequences. AAS analyse the concentration of elements in liquid sample based on energy absorbed from certain wavelengths of light (usually 190 to 900nm). Atomic absorbtion spectrophotometers typically include a flame burner to atomize the sample (most commonly a hollow cathode lamp), a monochromator and a photon detector. Depending on the model, some atomic absorption spectrometers are equipped with a turret of fixed lamp socket that can hold multiple lamps to reduce downtime between samples or allow for sequential analysis.

In atomic absorption spectrometry, a sample is atomized, usually by a flame or graphite furnace, and dispersed into the light. A detector measures the amount of absorption in the sample and compares it to a reference with a known concentration of the element in question to determine its concentration in the sample. Some of the specifications in an atomic absorption spectrometer are its wavelength range, type of atomizer it uses, can do multiple tests for multiple elements, and it has a single beam, double beam or both types of light source.

The sample for the present case is drinking water. Water is indispensable for human survival. It is not only required for body metabolic systems but also required for other associated activities with human life. Human body weight comprises of approximately 70–80% water and it contains approximately 99.5% of all molecules containing water. Water plays an important role in biological process and also it carries nutrients to the cells, it maintains energy production, and removes toxins from the body etc. Types of water qualified for different purpose includes- minerals for drinking water, agriculture, industries and distilled water meant for laboratories and medical factories etc. The quality of water varies from source to source for instance spring water, stream water, tap water will vary in their components. The variations are due to natural make up or human activities. Presence of elements and compounds at different range/ level is influenced by geological and geographical factors and at times due to a difference in chemical treatment before supply. Though these trace elements often seem to be very insignificant, it plays an important role in human life. Low level or high level concentration of these elements has both beneficial and harmful effects. For instance, Chromium reduces fatty acids and cholesterol and regulates sugar and insulin rates in the blood, but chronic exposure to high chromium levels causes lung cancer in human. Copper is very useful element but long term exposure to high level of copper through contaminated food and water sources causes diarrhoea,

headaches and in severe cases kidney failure. Iron occurs naturally in soil, sediments and ground water and can be found in many types of rocks. Iron can be present in water in two forms; the soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colorless, and when exposed to air the water turns cloudy causing a reddish brown precipitate of ferric iron appears. Iron is an essential trace element for maintenance of energy metabolism and the prevention of iron deficiency anemia. Calcium and magnesium concentration in drinking-water vary markedly from one supply to another, mineral-rich drinking-waters may provide substantial contributions to total intakes of these nutrients in some populations or population subgroups. Water treatment processes can also affect mineral concentrations. Calcium and magnesium dissolved in water are the two most common minerals that make water hard.

Methodology

Atomic Absorption spectrophotometry has been used in the present case in determining trace elements of Cr, Cu, Fe, Ca and Mg. The technique involves the study of the absorption of radiation by neutral atoms in the gaseous state. The sample is first converted into an atomic vapour and then the absorption of selected wavelengths by atomic vapour is measured. The technique is also known as absorption flame photometry because all analytical applications of atomic absorption involves spraying a solution of the sample into the flame. The absorption signal is proportional to the concentration of the free atoms present in the optical path. The physical phenomenon first observed by Foucault in 1849 was converted into a popular analytical technique by Walsh essentially with the development of the hollow cathode lamp as the source of spectral energy for absorbance measurements. Walsh utilised it for analytical purpose and coined the name AAS. Five basic components of an atomic absorption instrument are:

i) The light source that emits the spectrum of the element of interest.
ii) As ‘absorption cell’ in which the atoms of the sample are produced (flame, graphite, furnace).
iii) Monochromator for light dispersion.
iv) A detector, which measures the light intensity and amplifies the signal.
v) A display that shows the reading after it has been processed by the instrument electronics.

Simple block diagrams of a single beam alternative current (a.c) and a double beam alternative current atomic absorption spectrophotometers are shown in figure 1. The radiation emitted from a spectral line source (mostly hollow cathode lamps or less frequently electrodeless discharge lamps) is modulated electronically (pulsing of lamp current) or using a chopper (rotating metal disc) and intermittently passed through the atomizer (flame or graphite furnace) where gaseous analyte atoms are obtained thermally and absorption occurs.

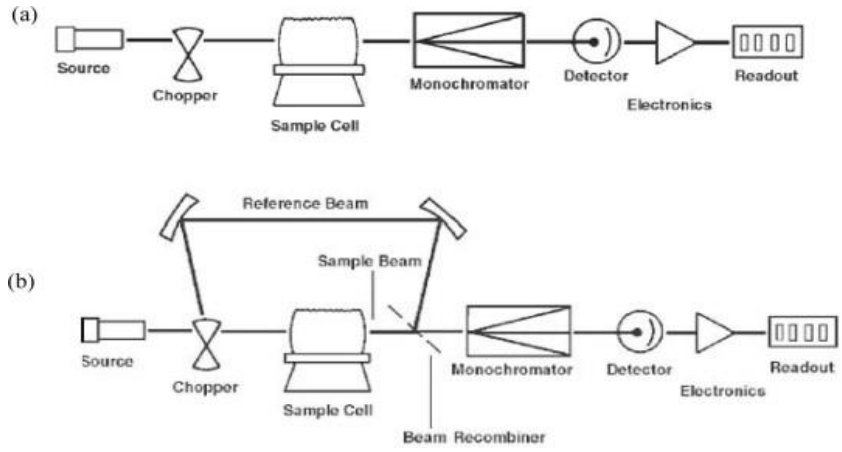

Fig. 1: Schematic diagram of a single and double beam atomic absorption spectrophotometer.

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Sample

Drinking water has been chosen as a sample for determination of few trace elements using AAS as the technique. 19 water samples were collected from few places in Shillong, Meghalaya in high density polyethylene bottles which have been pre-treated by filling with 20% nitric acid, pouring of the acid and allowing the inverted bottles to drain and subsequent washing in double distilled water and then with a portion of the sample. 300 ml water was taken from the collected water samples in a breaker and then boiled until the final volume becomes 15 ml. Since the water contained turbidity, filtration and pre-concentration was done. In this case the concentration factor=20

For example, if the Fe concentration gives 0.34 AAS reading then final concentration of Fe in the original water is given by the following expression:

0.34/20=X ppm

If the concentration of any element is very high, then the following procedure is to be adopted. Pipette 1 ml of unknown sample and then dilute it in 10 ml with distilled water. Suppose the AAS reading is Z, then

Z x 10=Y_{AAS} reading.

The concentration of the element in ppm is given as follows.

Y_{AAS} x volume of the solution/ Weight of sample=xppm

N.D - Not detected

S_1 - Water collected from the spring

S_2 - Water collected from the stream

T - Water collected from the tap.

Results

The results of the concentration of the elements (Cr, Cu, Fe, Ca and Mg) determined in the sample collected from the spring, stream and tap are shown below at table 1.

In addition to the determination of the concentration of the above few elements, the pH of the same water samples have been measured with the help of the digital pH meter Model No. 335 as shown at table 2.

Table 1

Sl. No	Location	Element concentration (in ppm)				
		Cr	Cu	Fe	Ca	Mg
1	Laitkor (S_1)	N.D	N.D	0.34	1.5	2.0
2	Laitkor (S_2)	N.D	0.3	0.14	9.5	3.1
3	Nongpoh(S_2)	N.D	N.D	0.51	3.6	3.8
4	Nongpoh(T)	N.D	N.D	0.31	10.1	2.3
5	Nongpoh(S_1)	N.D	N.D	0.26	2.3	2.3
6	Cherrapunji(S_1)	N.D	N.D	0.07	12.1	4.2
7	Cherrapunji(S_2)	N.D	N.D	0.07	7.5	3.7
8	Cherrapunji(T)	N.D	N.D	0.09	9.5	1.1
9	Mawlai (S_1)	N.D	N.D	0.53	3.3	4.1
10	Mawlai (S_2)	N.D	N.D	0.38	9.4	4.2
11	Mawlai (S_T)	N.D	N.D	0.28	3.6	5.4
12	Polo (T)	N.D	0.1	0.76	8.0	1.3
13	Lacchumeire (T)	N.D	N.D	0.21	5.9	4.7
14	Nongthymai (T)	N.D	0.4	0.15	5.0	2.8
15	Mawkhar (T)	0.1	N.D	0.08	2.4	2.0
16	Mawroh (T)	0.1	N.D	0.09	7.4	3.5
17	Mawplang (T)	0.1	N.D	0.60	5.3	3.4
18	Umsning (T)	0.1	N.D	0.15	4.5	3.7
19	Laban (T)	0.1	N.D	0.03	4.9	1.1

Table 2

Sl. No	Location	pH
1	Mawroh	7.33
2	Lacchumeire	7.29
3	Polo	7.36
4	Nongpoh (S_2)	7.35
5	Nongthymai	7.44
6	Mawplang	6.04
7	Cherrapunji	5.97
8	Nongpoh(T)	7.26
9	Laitkor	7.01

Table 3: Water Quality Guideline for domestic uses

Element	ICMR Standards 1975	Indian Standards 1983	WHO Standards 1983
Cr	0.05	0.05	0.05
Co	—	—	—
Fe	0.03	0.3	0.30
Ca	—	75	100
Mg	—	30	150
Na	≤200	200	≤200
Mn	0.05	0.10	0.50
As	0.05	0.05	0.01
Zn	≤5.0	5.0	0.05
pH	6.5–8.5	6.5–8.5	6.5–8.5

Chromium (Cr): In most of the samples, the presence of this element is below the detection limit of the instrument used which is 0.002ppm. Only a few samples, the level is above the pre-defined safe limit which is 0.05ppm.

Copper (Cu): The range of concentration of copper detected in the samples is 0.005ppm to 0.04 ppm though in most of the samples it is below the detection limit (0.001ppm) of the instrument. The areas from where Cu is detected are mostly samples collected from the urban areas.

Iron (Fe): The range of Fe detected in the samples is 0.03 ppm to 0.76 ppm. The minimum amount of Fe is detected in the tap water in some pockets in urban areas.

Calcium (Ca): The range of calcium detected in the samples is 1.00 ppm to 12.01 ppm. The determination of Ca in fresh water is important since Ca salts in water very often cause the hardness, scale formation and impart corrosive properties.

Magnesium (Mg): The concentration of Mg detected is 0.68 ppm to 5.11 ppm. Just like calcium, Mg also causes hardness, scale formation, and corrosive properties of water.

Conclusion

The above findings are very basic which is based on limited data. However it throws light on the importance of understanding the distribution of trace elements in drinking water which serves as the basic information for the future researchers to select the elements for controlled study and in establishing their critical limits. From the data it is observed that few samples from urban areas shows presence of Copper in the water which would have been better if Copper is absent. Minimum iron is detected in Laban

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while maximum amount is detected in the sample collected from Polo. However, by and large the concentration of iron falls within the limit which is considered safe for drinking water. The calcium and magnesium concentration is low comparing to Indian Standards 1983. The total hardness of water is the property attributable to the presence of alkaline earth minerals from the soil and rocks from direct pollution by wastes. More in depth research using atomic absorption spectrophotometry to determine trace elements in drinking water will be highly beneficial for human health. More analysis is needed to test other elements to determine quality of drinking water.

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References

Battacharya, P., Chatterjee, D. and Jacks, G. (1997). *International Journal of Water Resources Development.* **13**: 79.

Chakraborty, R., Dey, S. and Dkhar, P. S. (2004). Determination of few heavy metals in some vegetables from north eastern region of India in relation to human health. *Pollution Research*. **23(3)**: 537–542.

Clesceri, L. S. Greenberg, A. E. and Trassell R. R. (1989). Standard Methods of the Examination of Water and Waste Water. *American Public Health Association, Washington D.C, USA, 19th ed.*

Dkhar, P. S. (1996). Spectroscopic studies of the trace elements on rice, Oryza Sativa. linn. in Meghalaya [Ph.D. thesis], North Eastern Hill University, Shillong, Meghalaya.

Jamir, T. T., Singh, R. K. and Bhubon (2010). *Asian Journal of Chemistry*. **22**: 4657.

Manivasakam, N. (1994). Physicochemical Examination of Water, Sewage and Industrial Effluents, Pragati Prakashan, Publisher, India, 158.

Mukherjee, A., Sengupta, M. K., Hussian, M. A., Ahamed, S., Das, Nayak, B., Lodh, D., Rahman, M. M. and Chakroborti, D. (2006). *Journal of Health, Population, Nutrition.* **24(2)**:142.

National Research Council Staff. *Drinking Water and Health.* (1999). Washington DC: National Academic Press. **5**.

Pinta, M. (1978). Modern Methods for Trace Element Analysis by Ann Arbor Science Publishers.

Rubin (2003). Springs of Life. Garden of Life.

Singh, A. K. (2006). *Current Science.*

WHO (1993). Guidelines for Drinking Water Quality: Health Criteria and Other Supporting Information, *World Health Organisation, Geneva, Switzerland.*

WHO (2003). Total Dissolved Solids in Drinking-Water, Background Document for Preparation of WHO Guidelines for Drinking-Water Quality, Geneva, *World Health Organization (WHO/SDE/WSH/03.04/16).*

ANGAMIMIA KEPETSHÜ KEPEKROKECÜ KELHOUZHO (SOCIAL CULTURE OF ANGAMI'S)

Reviewed

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Puomho (Abstract): Phichümia thedze puketuo mu leshüko nu ngukelie Dzükezha khie lhou tuo di sünu nu rüyie se Khesora vor lhouta üdi pu tuoya. Thedze si saliekecü u pfütsau za Kezeiu üsi. Puoe Khesora lhou ba di puo nuo kenie nyilie . Phichüu za Vadio mu nhicuu za Tsiezieo. Nuo hanie-e Khesora nu kekhota di cha unie thetsera vota üya. Vadio liro tuo vor Mekhrora lhou di sünu nu puo yie kruo miemie parlie tse rüna kesa tsheketa sie Angamimia liro tsur Kigwera nu rüna tshelie di lhou , süla Kigwera üse Angamimia rünako donu kerietho-u üya. Kigwera lhou ba di themia kruo se parketa la keze thechü puo nu bakecü puo kere nyita. Süla rüyie kemeya se pa tsie Angamimia rüna chü kebako nu lhoulie. Mu tsie Angamimia rüna 113 ba mu rünako rhie kekrei pie Kicha dia chüpie baya. Kichako liro hakemhie:

a. Northern Angami (Chazouchamia) rüna 32
b. Western Angami (Niakrachamia) rüna 14
c. Southern Angami (Japfüphiki) rüna 18
d. Chakhro rüna 49 ba.

Angamimia kijü rie liro hakemhie:

a. Niathutsa : Chakhesang kijü. Thiedzü liro Chakhesang imo di Eastern Angami isi di kie vor.
b. Niakratsa : Zeliang mu Assamesemia kijü.
c. Pesotsa : Pughuboto, Rengma mu Lothamia kijü.
d. Pekhrotsa : Moamia mu Sepumarammia kijü.

Hakemhie di seyie kekreikoe Angamimia kijü houpfü baya.

Caü (Keywords): Krotho Bode, Rüna mu Kelhouzho. (Socio-Culture & Village Life)

Sededie (Introduction)

Diebo hau la thedzeko meho mu pfhü kevo cayie kenie nunu pfhüpie thulie. Mhapfhü kerieu liro rünako nu vo di phichüthoko ze kehou di thulie. Kekreiu liro leshüda thupie kebako nunu pfhüpie thulie. Phichümia ze kehou di thukelie rünako liro Kewhira, Viswema, Tuophema mu Khonoma.

Lhou keriemiako kimhie di kepetshü kepekro vor shi si mo thetazhiecü la siekelhoumia bu u kelhou bodeko sitoulieketuo kele se di hako pfhüpie thulie.

Krotho bode

Kikru

Kikru isi liro thenuthepfu pie unie nuonuoko pu ba. Kikru nu tsüphrü pete u mhatho kekrei phre. Kikru-e kelhou bodeu zo üdi puya kekreilamonyü kikru nunu mhathomhachü kouriko, mia thezie mu rhu morokesuo zhoko dojülieykezha la. Krotho kehoupuorei krüta puo khro nu mhachü bayakezha tuoi Kikru nu Miapuonuoe kikru Tsüu chüya. Puo mhatho liro kiülie nu mhatho kereko, tekhou kesa doukecüko, seidukecü mu chüterhü nu kevo thoko chü mu mehoya. Süsie kikru nu zuopfüe mhatho kemeyie huo liro tiecha gacha kesekecüko, puo nupfu puo nuonuoko pfhemenei pete mezatuo, lhacülhale pete kenyütuo süla puo nanyü se pecülie liro telha cü pu iya . U Tenyidie nu Kedeikepufü idi puyakezhau thepfumia pu ba mo derei thenumia kitiekinu lhacülhale kenyüyakecü nanyüko chüyakezha la thenumia üse kedeikepupfü idi puya. Kikru nu zuopfüe nanyü chü ba di puo kikru üse thie rüso rüchü kenyü isi liro sünhie rüso rüchüya mo . Kikruu nu nhicuko chüshü morokesuo kezhatho-u liro u krü dieze chükecüu zo. Kikrue krotho pete donu krotho kecütho-u mu kevitho-u zo kekreilamonyü kikru nunu kelhouzho kevi kekra silieyakezha la.

Chienuo

Pfutsanuo puo geinu lhou keparko üse chienuo isiya mu süu liro u krü thepfumia seyieko se u chienuo idi kieya. Thakie puo, mhanuü mia puo puonuo thepfu se mu thenu puo nyi. Thepfu sekoe u kiya chülieta üdi ukoe u krü

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u chienuo se motaya mo. Derei thenupfü puo kiya chüta mu puo kiya se pfutsanuo kekrei nu vota ro süsie puo krü chienuo khawa di vo puo nupfu chükecüu chienuo se tuotaya. Süla chienuo isi liro u krü thepfumia kitsa nu keyie kevorko pu ba. Chienuo mhatho kezhatho-u liro kekhruohikecüu zo. Sükosü kechükenyü tei, kesiakejü tei morei ketsopfhü kekrei rei lie vi. Mhanuü theruo kesuo nunu mia puo siata siro sünhie puo se kenyükecü la puo chienuo pete mhachü kenyütaya. Siro chienuo puo isi ba rei zha pengou senyü baya mu süla sükoe zhangou ketso kesia kenyü di ketsukevo rei chüya mo . Süsie chienuo puo chü ba di kesekerei kenyüya mhaca hako la:

i) Terhü nu mia zhalie motaya.
ii) Tekhou nu khunuo kekhriekezei lie vawa keprei la.
iii) U nuosenuoyie u lhe u lhou vi motayakezha la.

Kashükayie

Thepfumia u kiülie mu u nya u ra kezapie u nuonuo thepfuko tsüya mu hau üse kayie isiya.

Thinuo

Chienuo kekreikecü keze vor thepfü puo chü keba süu üse thinuo isiya. Thinuo nu themiakoe kenourhe mu kenousi pevikelie geinu mhathomhachü kehoupuo kechü nu rei chü khrielieya. Thinuo üse Khel isi reiya mu hau nko die mo di Tephriedie. Thiedzü kekramia vor nko kekhakecü teiki rüna puo zorei kezapie za dia morei se chü phrewa mu sidi Goanbura puo bu thepfü puo mehokecü chüwa, hateiu nu ukoe thinuo hau pu reketa la Khel idi kieta üya.

Kichüki

Rüna pete nu kichüki ba phreya mu kichükiko nunu themiako mha kevi kekra dojü mu silieya. Siro thepfuko mu thenuko ki kekreiya kekreilamonyü u rnhatho kekreikecü la. Thepfuko liro kichüki nunu merha rnerüko do dojü, sei rhiko dojü, thedze morokesuoko kerüchü mu thepfhe dojü iya. Thenuko liro zotsha ze di pfhe do dojü, kelhou zhoruli keviko se ketarho ibaya .

Kichüpeli

U pfutsanuokoe liecielierhi chü di u va kracü mu kishükinyi pfhü vorkecü la khriesarüü parta ro keze peli di rnhathomhachü nu huoniehuo khruohi idi keze kepekro ketheguo phi vor . Kichüpeli kechü thetshü thetshü idi baya mu süla kikru huo nu themia khriesarüü kemetha ba liro keze peli puo nu rei baketa rei nyi. Derei süu la üdi kezekesuo morei kengu rnecüketa chüya mo. Siketau monyü chülie keviko nu kedieze di kekhruohi unei phi baya . Peli puo isi ro puo tei pete nu kesiedzi mu kekhoya siro mhatho teiko nu rei , kernezhiekelie tei nu rei , thenoukesuo mu kenei teiko nu rei keze kekrotho di kepekro vor. Kepekrokecüko donu kichüpeli hau se kemeyietho chüya kekreilamonyü u tsiepfumiakoe liecielierhi chü kevor la. Siro puotei kckreikreikecü ki ze mhathoko rei kekrei phreya. Sikecü la kichüpeli se kenieputho mu uko kenietho-u chü vor. Peli puo nu tsüphrü mia ser morei sümho ba phreya. Mu mhatho teiu ze di pelikecü rei nyi. Tekhouhie, dizhü mu mhatho kekreiko nu liro mia ser morei mepfüe ki keze pelilieya derei khoutho teiki cüsie mia thepfü ker keze pelikelie pie kekratho chütaya. Puo thuo themia tsa rei kra rei pelituoketa sie keze uko nei mu uko noumvü phikecü chü tuoya.

Kracü

Peli puoe puo khriesarüü vi kemetha ba ro kechielie di thekra cüketuo ralieya . Mu hau ralieta tse kichüpeli lieko nunu thepfhetheü doju sedetaya kekrcilamonyü kracü liro u pfheü keviko se mia pekiekecü chüyakezha la. Süla thepfhe kekreikreikecü dojü seya mu hako dojüketuo la chahechüko chüpie ba di khinhie tsu mhachütuo di thevatie vorkezhü ki chahechüko nu balie di thepfhe dojüya . Thekra kecü hau liro Sekrenyi zha dia nhie thevatie le theba nu bataya sidi süsienhie balie di zha se nhie nu laya , Kracü ha u keneitho tei puo mu rütsonyie pete se di kerütsoyakezha la kesiakejü ba kemo teiu nu chüya.

Rüna

Rüna puo nu thinuo se dia baya. Rüna pete nu thepa mu thevo ba phreya kekreilamonyü thepa mu thepa kerei kenyü mu thevo mu thevo kerei kenyücü la. Süla thiedzü kerieki thepa mu thevo unie bu kecie di rüna pfhüya üsi. Thevo yiemiako liro phichü mu u krü kiekecü apuo,

azuo isiya. Thepa yieko liro nhicu mu süla u krü kiecü apfu, apfü, apfo apfo-o isiya .

Rüna tshekecü

Thiedzü u tsiepfumiako rüna tshekecü puo zho krei seya. Ukoe nanyü se pecüthorkecü ki ze mha kehoupuo kechü nu rei nanyü chü perieya. Süla rüna tshekecü rei peyuo di chüya mo. Rüna tsheketuo la mia kro puo kechielie di tuo sedeshütuo.

Uko tuo vo thechü uko kenei ngulie ro rie menuowa sidi nha rhopie zhüwa di la pesie uko kinu vota di süzhü uko mho rünyüya, uko mho vi ro süsie tuo la se thechü riepie kebau nu votuo derei u mho suota ro thechü süu khawa di kekrei pfhü laya.Mhanüü uko mho vi di thechü uko pfhü pie kezhü nu vo ro nha rhopiekezhü-u mehoya, meho kevo ki uko nha rhopiekezhü-u nu tuoicü nhico coru vo bvü ba ngulie ro thechü süu nu themia kruolietuo derei terhümiavimia lhoulie lho ha isi thaya , süsie rei nhico cokhrie bata ro themia kruolieya mo derei terhü-miavimia lhoulieya . Mha hako la üdi khawaya mo derei rüna chüketuo la phe tshelie di bataya . Siro rüna tshekecü puo thouko geinu tsheya. Mha hau chükecü mha kekrei la mo derei thiedzü terhü kenyi la u mhitsie kevira balie ro u rümia ngu peviya üdi hau chüya. J.H. HUTTON leshüda nu rei nko dze thukecü hakemhie, ‘Angamimia rüna chükecü kijuthou geinu sede di rüyie pesu tsurya”, Die hau kethotou kekreilamonyü themia kruo parta liro rüyie pesu tsutaya.

Rüna Dahou

Rüna pete nu thinuo pete rei puo thuo puo dahou ba phreya. Dahou liro ketsie pfhe kerükrie selie di sügeinu themia bako ketsie se dzelie mu tsiekra se vor di süko se chiela chüya. Penie teiko nu phichümiako vo dahou gei ba kehou di thedzetheseko pu nhicu khriesako pekie baya.

Rüna cahou

Rünau khieumhouko nu sokro leipie hou vo baya mu süu se rüna cahou isiya. Sokro liro nha puo hu chükecü puo mu puo ro chü di kepele phapfü baya mu süu pfüpha re seya. Siro puo huko the pesieyakezha la pfüpha pa liro u teshü pesie mu u gou sewaya.

Kharu

Kharu liro rüna care-u zo Kharu nunu ketsukevo nanyüko chüya, sikecü la rüna pete rei kharu ba phreya. Kharu chükctuo la seipe se morosuoya. U tsiepfumiakoe nanyü kechü nu sei puo mezu kete se nanyü chü kenyüya süla sei vi se ba zorei puo mezü teta ro se kenyütaya . Ketsa nunu sei-u wilie di puotsie nunu kharu rhiu rhilie sidi teshü tsur cha tsokelie ze nu ketso kezivikecüko chü voya , Siro kharu khapie baketuo la puo khie lutsahatsa ketsie se pfhe menuo mu pfhe kemetei se morosuo kekreilamonyu kharu nunu themia mu kicükiri pete kepra kele cha chüyakezha la. Süla kharu khawata ro pa mu lelie suotaya . Siro thiedzü chüterhü kenyi la kharu khawa ro ketsie kezha puo ketupie puo sietsa touwa di chazou nu khrülie kenjükecü chüwaya süla kharu khawa ro ngumvümia rei vorlie kenjütaya. U Tenyimia kharu puorhi kekreikreikecü baya derei puokrau zowe puozha thu pengou (5) mu puo rükrie thu thepfü (9) mese ki baya üsi. Rüna kekreikecü ki ze kharu gei mharhiko rei kekrei zazaya derei puo rhi kemeyietho-u sü mithu tsü puo rhipie kharuu tshunuolie mu mithu kianie donu thepfumia nyie sekecü themia mharh**i** puo thaya. Haki nu kharu rhi yopuo thushüzhie. Mithu tsüu rhipie kharuu tshunuo pie zha. Mithu zieu methou se par, puo mhi, puo nyieto, mu puo kia rhi pecha se pie ba. Mithu kianie donu themia se rhipie tha, metsuo nu kethau zha mu puo khienie cü. Themia mharhiko thepfu nyie se phre. Thezatsa kethau rüngou kethe mu pezhü yopuo puo phi ki tha. Thevitsa kethau rüngou yopuo kethe . Pesotsa kharu nu rhipie jiepie vo zha mu mithu kianie khietsa liro thcmia tsü kro puo rhipie zha. Kharu nuko khronu lutsahatsa khrüluo kezha puo mu kecü puopuocü rhipie zha. Süsie pekhrotsa kharu nei rhipie zha.’ Mharhi hako puoca kekreikrei phre. Mithu tsü liro u zha u zhü vakeliemia zasi mu hau rhikecü rünau nyi keba thakeshü zasi. Themiau liro terhümiavimia kharu pfhe ketha rhiu kekreilarnonyü mharhiu vathou pedzü kelie tha mu hau terhü sakramia zasi. Siro Ramei lapfü kethau liro terhü kegeimia rhiu mu terhümia rüna sünu keba zasi. Rüngou pezhüko liro terhu nu u zha vilieketuo rhi thakeshü, Kharu kro puo liro telha bo mu puo kre rei rhipie zhaya mu süu liro lhacülhale kecha rhiu, kharu nuko liro themia kelhou chakecü rhiu. Mithu rhipie kebako liro kicükiri chakecü rhiu idi puo zasiko kekrei phreya mu zasi hako geinu lhou keriemiakoe huoniehuo rüna dze silieya .

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Rüükhouba

Thiedzü terhü kenyi la rüna pete nu rüükhoumia baya mu hakoe vo u mhitsie kevira nu ngumvümia kevor pfhe baya. Süla Rüükhouba liro chüpie kharu khie morei rünau khie mha tsie pevilieketuo ra nu chüya .

Rüna kekhriethokecü / Kekinyikecü

Rüna kekinyikecü puoca kenie nunu kepushüzhie. Kerieu liro thiedzü terhü kenyi la rüna kenie rei kezevi keba tei penyiya . Süla phichümiakoe meho ba di u donu kezekesuo hau pejüwa di kezevilie morokesuo kele nunu kekhrietho sedelie üya . Ca kenieu ro thiedzü nu u pfutsanuoko keze kepeza di khrietho chü kevor-u pejüwa suo üdi kekhrietho kesa lakecü nunu sede . Rüna kehoupuorei puo nuolhou vi kemetha keba teiki mhatho hau ralieta ro Terhünyi teiki vo mia kieya mu mia kieketuo la pehümia u peyu kenyi kro puo pie khriesa kevi kro puo sa voya. Siro u kelhouzho nu ketheziethoryakezha ki ze mia u kie kevo rünau rei kekinyi nyü ba zorei kerüzhie mu kethezie se di die puya . Mhanuü kerüchü kevo nu rüna kenienie rei u medo phreta ro kepfhekholie di phichümia bu terhuomia ki mha kevi chalie di kekhotatuo. Siro, rüna kekreikecü kize thenyi teiko kekrei phretaya. Kewhimia liro kekinyikecü Sekrenyi zha thetha nhie tuo sedeshüya. Rüna kekinyi nu themiako kerütso phiya. Phichümia khe pezhü pfüya mu khriesamiako rübei tsüla terhanuoko seyakezha zo. Vo mia ki hietuou keba themiakoe dojü tseilieta tse vo di ziekeko nunu kepfhelie di u thako keselie di tuo chieshütuo. Siro tuo chieshüketuo la thuophi-kepfümia bu rieya mu hakoha liro terhü theshamia mia kenie mu siezedzürie phousemia kenie idi nanyü cau pfütuo. Ukoe u rüna nunu zumho shüpfü votuo. Rünau cha cha liro khunhie vo tso reketa nyiya süla chalanu rüna u khrietho thinuo huo nu zhütaya. Derei nanyü ca kepfüko zowe tsenhie vo rünau tso morosuo beiya, süla kemezhie se zorei kethehie di vo rünau tso bei morosuo. Vo rünau tsokelie ki mia pesotuoü keba rünau rei u somia zelieketuo la u terhü dojüko chüpfü vor pfhe ba di lutsahatsa rei kepenuo za volie tse thalie di mhopie vakecü nanyüu chüya . Mhopie vakecü hau lelie kemo nanyü puo. Lutsahatsa rei u ngou pie huohuo kesu di diebe di ja thaya mu ja ketha ki u phikrü kelepie mia kitie sei thathaya . Thuophikepfüue ja di:

“A vüdzüu no vügupfü,
N bu a kelho kenyü chütuo’, ithaya .

Mhatho hau tseiketa sie tuo se phenu pata di vo rünau zieke nu le di mechü rülou chütuo. Rülou tseikewa sie mia pesotuoü keba rünau-e vo u somia puopuokecü te phrelietaya . Siro mechü rülou tseikewa sie lutsahatsa rei nanyü ca kepfümiakoe zieke nunu kehieli di mha metha khrüya. Mhatho hau chükewa sie kekreiko rei mhacümhakrie sedetaya. Süsie, mia mia somia ki vo phretatuo derei thuophikepfüko zowe vo ki puo kifükhro nu zoprie se bo houshülie di sünu baya. Siro thuophikepfüko peso kebau rei puo soko theke kebau sie mha phrapie chazou shüya mo. Vo tsezhü we mechü keze hie mo di terhüba morei kilha kilha thuo u somia ze vo hietuo. Süsie nhie ba nyiya mu süu liro mechü pete vo di keze hietuo, thecathebie rei chü, thepfhetheü rei chü mu phichümiako ba di thedzethemiako kerüchü ivoya. Siro hanhie zowe thenuthenuo pete rei vo mia meho di thecathebie kevimia mu thepfhetheü kevimiako tshe phi thaya . Süsie, zha se duü sie tuo lashüketuo la dojü sedetatuo. Haduü we niepu-ue puo somia bu mhacümhakrie menuolie, sümhonu puo muo dzeshü, puo shü pelishütuo . U rüna nu ba di tuokeshü duü kemhie di haduü rei dojü phrelie ro vo ziekeko nunu kepfhelie di u thako keselie di tuo lashüya . Sidi vor u ra tsoleita ro mia ra kele ki tuoi tuo le zieke nunu mechü rülou chülie di u kitiekinu votaya üsi. Siro rüna puoe ciethie vo mia ki hielieta ro süsie pecha mo di mia bu la vor puo ki hieketuo la dojü bataya. Mhatho hau kechü geinu rüna rüna di keze kekrotho mu kenousi pevikuo salieya .

Kelhouzho

Phichümia rhukecü

Kelhouzhoko donu u kenei puo liro phichümia rhukecü kekreilamonyü puo thuo vi shierei suo shierei, mhasi rei si morei phichümia sü phichümia zo üdi leya. Kehourapuo tuo rei phichümia ngu ro u rüchü riekecü mese (kekrüketa keprei la) siro kecükekrie seketa mhodzü rei phichümia bu theja chashü di mha metha rieya. Mhatho hako pete rei therhu se phichümia tsükecü la chüya . Die puo pucü ‘Niaki kele tieki rei phichümia dieze morosuo”, isiya. Hau ca phichümia nei mo chüwa ro kekrütaya mu terhuomia rei u nei motaya üdi l phichümia puwata ro süu chü morosuo iya.

Kedietho mu Kemiatho

U Tenyimia kelhouzho nu kemiatho mu kedietho kelhou-e puo therhu kezhatho mu puo peyu kerükrietho puo. U tsiepfumia hanie se pecüthoryakezha la u vie kemo mhakipuorei bieya mo. Diethokecü ki ze kerügu rei tsa phiya . Siro bie kenyü, chü kenyü isita ro mia puo süu vacieya mo. Hanie se pecükelie geinu mha kekra nu rei chü khrielieya. Diethothorkecü la kikha zorei sei kenie kevücie pie ciewayakezha zo mu süpfü la üdi mhapuorei pejükewa siya mo .Süsie chatiechala nu raka petepiezhü di ngulie zorei süu se u vie chüketuo michieya kekreilamonyü u vie kemo nya kehoupuo ngulie rei lie kenyü üdi se kepesiwaya di niepumia u vie pejükewamia tsüwaya . Hakemhie di Ihou pecüthor vor .

Huoniehuo khruohikecü

U tsiepfumia mhatho u neiyakecü ki ze mhakehoupuo kechü nu rei huoniehuo khruohi vor. Süko liro kepfükepie teiki mhatho teiko nu, kemezhiekelie tei ikevo pete nu kekhruohiya. Kenyimia rei kejümia khruohi di u bu u zha pie cü di lhou vor. Mia puoe kechükenyü chü bata rei themiakoe puo chü morokesuoko nu kekhruohishüya derei süu la üdi u zha pie cütuo icü baya mo. Siro ketsakechiemiako rei khruohishüya.”

Kelhou thau mehoshü ro kerükrie kerünuo chüya mo. Themia pete thau ketou di lhoukecü puo lhou vor kekreilamonyü kenyimia rei kejümia peseya mo, kesimia rei sikemomia peseya mo. Süla kelhouzho meho kevo ki ketheguo mu u nei phi di lhou kevor ngulie.

Ütsali

Hau rei kelhouzho u kenei puo kekreilamonyü hau geinu rei themia kepekro pevi se baya. Mhathomhachü pete nu thepfhe baya mu thepfhe süko chü di kemezhiekecü vovü rei si mo u nei se tuoya.

Krüta mu peyu dze

U tsiepfumia kelhou nu krüta mu peyu dze ha meyie se. Peyu isi liro thenou mhasi-puoca puo kele puo mharhü vi sekecümia pu ba mu krüta iliro mia taze mhachü, mia cha tha tuoyakezha pu ba. U tsiepfumia zhonu krüta mu peyu kevimia zhoko meho menuo kevo ki themia kekra therie ki kekhrie mu nouzhie siro kenousilie kevi die kemene se kezesuo keba kronie lutsahatsa rüchü ba di kemezhütho zho nunu tseiüvi pie ketsülieya, mu hakemhieko nunu kezesuo talie kevi kikru morei krotho kekra rei kenousi lalie mu kejo vapie huoniehuo tsülie di süsietsa mia ki rei kepenuokuo tuoketa nyi phiya. Krüta kevimia kemiakoya mo tsiu thenou kerünuo nouleu se u themiako tsüya.

Peyu-e kayie geinu monyü mialiu kevi geinu parya. Peyu yiemiae peyu chü rüüya üdi puya Kekreilamonyü u krü ze di kesiedzi morei u khiera tuo di u krü die rünyü di sikelie la mhasiu u gei tuoya. Peyu ha mha kekra nu pulieyakezha tsiu krütamia gei kekuo hau ba morokesuo la hau cha kro puo thushüzhie. Peyu ha krütamia ramei kemeyietho-u. Hau liro mhasi donu thenou mhasi ze kepero pevikuo. Mia puoe puo kelhou nu miavi chü di lhou tuoya rei puo peyu ba kemosie miaüumia donu thetshe pfüya ürei mechü donu die pu re mu puo kethepfu jü ro puo üse peyumia ücü kielie reya mu peyumia thau prakelie mhodzü krütamia chülieya mo. Süla peyu mhasi-e kelekemedo nu rübei mo di kepu nu rei sa ketoukerü morosuoya. Haha la we peyu üse krüta chüketuo chadiu morei ramei ücü puya. Krüta thau praketuoe peyu thau pra rie morosuoya.

Rüna nu krüta mu peyu kedakecü zho

U tsiepfumia kelhou teiu nu leshümhasi tuo mo süla kelhoumhasi, thenoumhasi mu ruopfümhasi, hako geinu lhou vor. Krüta chüketuo la mia puoe hakhro thupie kebako puo gei tuo morosuoya.

i. Therietho nu puoe thenoumhasi puo gei tuo morosuo kekreilamonyü mhachü kevo nu kevi kesuo, kedietho mu kemeda, ketho mu ketijü, hako parya mu puoe hako si kekreilie mota liro mhachü kevo nu kekrütayakezha la.
ii. Puoe puo nourhei morosuo kekreilamonyü thiedzü chüterhü kenyi la kehoukirei mha kere sierketa nyiya mu sita liro puoe puo mhale sou mu tseiphrei di mechüu cha thalie morosuo.
iii. Puoe diechie mu diekourei se si morosuo kekreilamonyü puoe diepu kekrükeshü geinu mechüu puo gei ja mu rünou mo tuotayakezha la, Siro dievi puo pucü ‘Die ha u kevü ki rei chü’ üya. Süla puoe hanie se sikelie geinu mechü nu theshie kere kekra kekhalie vi .
iv. Puoe krüta praketuo la peyu thau pra rie morosuo kekreilamonyü puo thuo miavimia

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chü di lhou tuoya rei puo peyu ba kemosie krüta chü di lhou tuoya rei krüta kevi chülieya kemo la. Süla peyu ha krütamia ramei kemeyietho-u üdi puya.

v. Puoe puo zho puo rüli vi di mha kehoupuo kechü nu rei shügeshühie morosuo, puo kicükikru puo siezanuora mu puo ramia mhodzü nu kekhrie penyi di mia khruohi nyü sieikecü chü morosuo, süsie ketseikevi nyi mu mediemerhie di mia nei chü si morosuo, puo thuo puo pie kenuou chü di puo themiako se kerieu chü morosuo. Mhanuü mia puoe puo gei mha hako ba liro sümia üse krüta kethomia üdi mechüu thuo puo kedashüya .

Thekhadie (Conclusion)

Ba hurei Tenyimia donu Angamia üse pede di lhoukecü seyie kekreiko ki vikuokecü ngulie themia lhou rüyie kevor ze puotei rüdi phitazhie. puotei rüdikezhü ki ze kelhouzhoko rei rüdi rükri phite mu süla tsie kelhoumiako rei mu siekelhoumiako rei u krü u pfutsanuoko kimhie di lhou vor shi icü si motazhie. Süla mhathu hau nu phichümiako ki thedzeko pfhü kevo ki rüna huo kekreiu ki puo zho krei zatacü rei ngulie derei puo bothoko liro pete khre rei kemhie khre lakecü nguliewe. Süla u kelhouzho hako pekru menuo se tuolieketuo u zha chü phre morosuote.

Kekhruohi Leshüdako (References)

Hutton, J. H. (1969). The Angami Nagas, Oxford University Press .

Shürhozelie (1982). U Tsiepfumia Rüve,Ura Academy Publication, Kohima, Nagaland.

Shürhozelie (1992). Tenyidie Dze, Ura Academy Publication, Kohima, Nagaland.

Sorhie, V. (1993) Tenyimia Kelhou Bode, Ura Academy Publication, Kohima Nagaland

Thinuo, L. (1992) Sewe, Lhisemia Thinuo, Kohima Village.

Zhale, K. (1995) Tenyimia Kelhou Dze, Ura Academy Publication, Kohima Nagaland

IMPACT OF MANAGEMENT ON RICE YIELD IN WET TERRACE RICE CULTIVATION

Reviewed

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Abstract: A comparative study was conducted to appraise the management practices of Wet Terrace Rice Cultivation (WTRC) in Jakhama, Mima and Meriema villages of Kohima district. The objectives were to evaluate the traditional management practices and its impact on rice yield. Rice yield was found to be 61% greater with organic manure application than non-application. Although, there were differences in several management approaches among the villages, the rice yield did not show significant difference between the management approaches in the selected villages. These results suggest a requirement for thorough evaluation of various management practices to develop a best management practice in WTRC for improved rice production.

Key words: Nutrient management, Rice yield, Terrace rice cultivation.

Introduction

Wet terrace rice cultivation (WTRC) is a system of irrigated agriculture for rice production popular among the Angami and Chakhesang tribes in Nagaland (Saikia *et al*., 2008). These two tribes have a unique way of cultivation using special indigenous tools and devices for construction of terraces with indigenous arrangement of water system in the terrace rice fields (Saikia *et al*., 2008). Terrace rice cultivation (TRC) constitutes about 120750 ha of the total net cultivable area of Nagaland (Directorate of Economics and Statistics, 2018). Terrace rice cultivation is divided into permanent and temporary WTRC (Jajuo, 2013). When there is sufficient water available and the field is kept flooded throughout the year, it is referred to as permanent WTRC. Whereas in temporary WTRC, water is retained in the fields only from the time of transplantation until the paddy ripens for the purpose of sequential cropping or because of limited irrigation facilities (Jajuo, 2013). In WTRC system, management of the terraces is one of the primary requirements for a better yield (Reddy, 2009). Despite the importance of WTRC to meet the local rice demand, farmers are facing challenges because very little is known about scientific approaches towards management of terrace cultivation in Nagaland.

Rice management can be divided into four stages depending on growth stages of rice crops: nursery, vegetative, mid-season and late season. Nursery is from sowing till transplanting (25-40 d), vegetative is transplanting to panicle initiation (45-90 d), mid stage is the period from panicle initiation to flowering (30 d) and the late stage is from flowering to full maturity (30 d) (Talpur *et al*., 2013).

The traditional method of preparing land for transplanted rice is tillage of soil in standing water commonly known as puddling. It is a technique for making seedling transplantation simpler with least injury, weeds suppression, reducing percolation loss of water, limiting irrigation needs and making the soil less compact due to standing water which increases the porosity and accessibility of nutrients (Reddy, 2009; Reddy and Hukkeri, 1980). Organic manures, particularly farmyard manures (FYM) and green manures have traditionally been used by rice farmers of Kohima.

Transplanting is a critical step in paddy cultivation because plant spacing and planting density during transplanting affect yield (Dejen, 2018). Plant density influences the yield potential of the rice crop and formulation of the right measure for pesticides and fertilizers' application (Bakar *et al.*, 2018). A spacing of 20 x 15 cm was reported to be optimum for rice yield (Rao, 1969). Water requirement of rice is higher than that of any other crop. Hence, guaranteed and timely supply of water and subsequent land submergence is required which improves the

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yield (Singh *et al*., 2009; Reddy, 2009). Rice is harvested at around 14-16% moisture and timely harvest is important to prevent grain losses of up to 5-10% (Reddy, 2009). Other important aspects that affect yield in terrace cultivation include water management and disease and pest management. Coordinated management of all the above components can enhance productivity and achieve optimum benefits with minimum damage to the environment. This study attempts to evaluate the present approaches of farm management in the WTRC system in three villages of Kohima district and understand the impact of management on rice yield.

Materials and Methods

Study site and design

Three villages, Jakhama (25° 35′ N, 94° 07′ E), Mima (25° 38′ N, 94° 06′ E) and Meriema (25° 41′ N, 94° 06′E) were selected for this study for the cropping season of 2019. Field surveys were conducted using interview method and on-site measurements of quantitative data were collected during the month of October 2019- March 2020. Ten farmers from Jakhama and five farmers each from Mima and Meriema were randomly selected among larger farm sizes for both qualitative and quantitative data collections.

Data collection

Data collection was done by interviewing the farmers using questionnaires. The interview was conducted when the farmers were working in the field so that a direct observation could also be made.

A. Quantitative data collection

Area of the field

Length and breadth of each terrace and the entire field were measured to determine the farm size. Additionally, bund height, terrace width, water depth and distance between plants were measured.

Plant density

Planting density in m^2 was evaluated from five quadrats in each terrace by manually counting the plants. This was compared with the seeding rate estimate given by the farmers in kg per area.

Rice yield

The rice yield measuring tools used by the farmers were different for each village. Jakhama used different baskets with sizes ranging from10-20 kg, Mima used 18 kg baskets and 40 kg sacks and Meriema used 40 kg sacks. In order to have a uniform estimation of yield, harvested rice was collected using a 250g cup from each farmer at the time of harvest and their initial weight was taken. Rice was oven dried at 60°C to constant mass, and then the weight was measured. Total yield was obtained by multiplying the dry weight into total number of cups to fill the farmer's measuring tool into number of basket or sack of rice yield by the farmer. The final rice yield was adjusted to 14% moisture for reporting by using the formula:

Yield at 14% moisture = Yield* [100/86] (Li *et al*., 2009).

Time investment on farm management activities

Data were collected for various farming activities such as nursery management, puddling, manuring, transplanting, weeding and harvesting. For each activity, farmers were interviewed about involvement of number of labours and days spent to complete each activity. The daily individual labour hour was estimated at seven hours per day.

B. Qualitative data collection

Labour involvement and time spent on different stages of cultivation, type of cultivation (permanent wet or temporary wet), pre-planting activities (puddling, rice nursery, manuring), in-season management (transplanting, irrigation, manuring, post-harvest management, month of different stages of cultivation (nursery, transplanting, weeding,

manuring, irrigation, harvesting), cropping system and rice yield were collected from each farmer in each location.

Statistical Analysis

The data were analysed using one-way Analysis of Variance (ANOVA) and independent *t*- tests assuming unequal variances at $P \leq 0.05$ in Microsoft Excel (Microsoft Excel 2010) and SAS®Studio (SAS 9.4, 2016). The independent variables assigned for the ANOVA were location (Jakhama, Mima and Meriema) and types and use of organic manure. The dependent variables were rice yield, farm size, seeding rate, time investment, planting density and manure application rate. The homogeneity of variance was tested using Levene's test. Mean comparisons were made using Tukey- Kramer test. The two sample *t*-test was performed to check the effect of application and non-application of organic manure on rice yield across locations.

Results and Discussion

Types of terrace rice cultivation

Two different types of WTRC, permanent and temporary WTRC were observed from the three study locations. Among the total of 20 fields studied, only 3 farms were found to practice permanent WTRC. Compared to temporary WTRC, permanent WTRC had on averaged 26, 61, 62, 22 and 21% greater planting density, manure application, farm size, water height and rice yield, respectively, but 4% lesser seeding rate (Fig. 1). Although, the farm size was bigger in permanent than in temporary WTRC, there were no differences in relative proportion of time spent for puddling and weeding within each cultivation practice (Fig. 2). The time spent in permanent and temporary WTRC, respectively, for nursery management and transplanting were lesser by 5 and 6%, and more by 10%. The average time spent for management activities evaluated in this study was 548 hrs for the permanent WTRC and 323 hrs for temporary WTRC. This difference may be attributed to more overall time investment for various management activities in permanent WTRC compared to temporary WTRC because of the larger averaged farm size of the permanent WTRC (0.21 ha) than the temporary WTRC (0.13 ha) in this study locations. Additionally, this was a single season study with limited representative farms and exclusive of other management factors which may have contributed to large variations in the data.

Rice yield

The rice yield was not significantly different among different locations, Jakhama with 2.69 Mg ha^{-1}, Mima with 2.57 Mg ha^{-1} and Meriema recorded a yield of 2.87 Mg ha^{-1}. The average rice yield of the three locations was 2.71 Mg ha^{-1} during the 2019 growing season (Table 1). This yield was close to the average rice yield in India during the year 2018-2019 which was 2.66 Mg ha^{-1} (Directorate of Economics and Statistics, 2019) but much lesser compared to the world's leading rice producing countries such as Japan with 4.91 Mg ha^{-1} and China with 4.79 Mg ha^{-1} (Gadal and Shrestha, 2019). Rice yield in India should increase to at least 3.25 Mg ha^{-1} by 2025 to achieve the projected 140 Mt demand of rice (Reddy, 2009). There is great potential to increase rice yield in Nagaland and India with proper implementation of System of Rice Intensification (SRI), which proposes 7 to 20% greater yield with 30 to 40% reduced irrigation (Kumar *et al*., 2016). This can be achieved by preparing high-quality land with nutrient-rich non-flooded nurseries, use of young seedlings for early transplantation, wider spacing, use of compost farmyard manure (FYM), careful water management, and frequent weeding (Kumar *et al*., 2016). In Kohima, it is often misunderstood by the farmers that rice requires submerged conditions for higher yield. However, SRI proved this wrong and generated more rice in moist water condition along with less water consumption through proper management practices rather than continuous submergence. This has also been introduced by the Department of Agriculture in Nagaland. Several trials have been done, however, it has not been put to practice by the farmers as it is considered labour intensive and time consuming. Recent studies in Vietnam reported that SRI is easier to practice and the

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additional time needed for weeding was exactly compensated by decrease in land preparation (Uphoff, 2006). Once the farmer perceive the reduced water requirements, seed requirements, cost of production and most importantly higher yields, SRI can be very beneficial for farmers as it can highly decrease water consumption and vastly increase yield rate. This is very important to meet the global average yield and feed the growing population.

According to the farmers of Mima village, they received late annual monsoon rainfall and therefore were unable to start their cultivation process as usual. This may have contributed to about 8% lower rice yield compared to the average of Jakhama and Meriema, despite absence of significant differences between villages. Drought is considered to be fatal for rice production, especially rain-fed rice (Rahman *et al*, 2017).

Although various types of manures were used by the farmers, a proper recommended and systematic integrated nutrient management (INM) was lacking in all three villages. The farmers applied the manures only as much as their livestock could produce in a random manner. Therefore, this lack of proper nutrient management may adversely affect yield because fertilizer management alone can account for 50% of yield gap (Dinesh *et al*., 2005). In the study area, majority of the farmers used landrace seeds which might have been a contributing factor of reduced yield compared to other places where high yielding varieties are used (Gadal and Shrestha, 2019). Introduction of new improved varieties may improve the yield in the terrace field in Nagaland.

However, differences in management approaches and skills, climate variability,

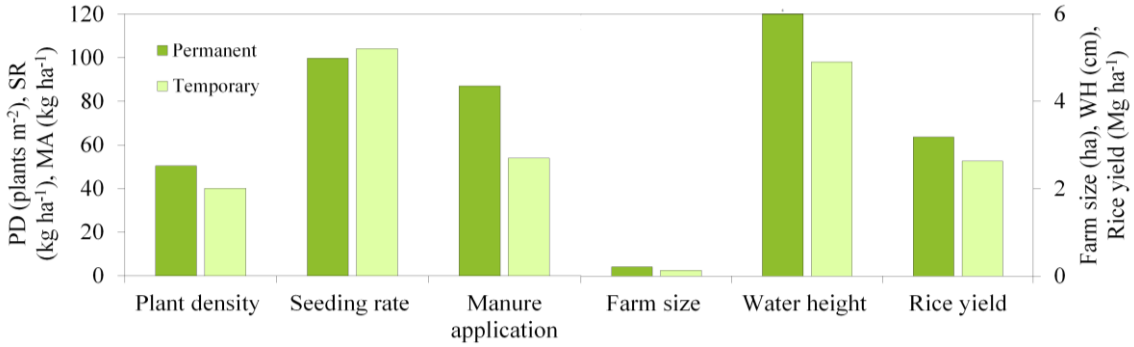

Fig. 1: Bar graph showing the different components of cultivation under permanent and temporary wet terrace rice cultivation. PD, Plant density; SR, Seeding rate; MA, Manure application; WH, Water height.

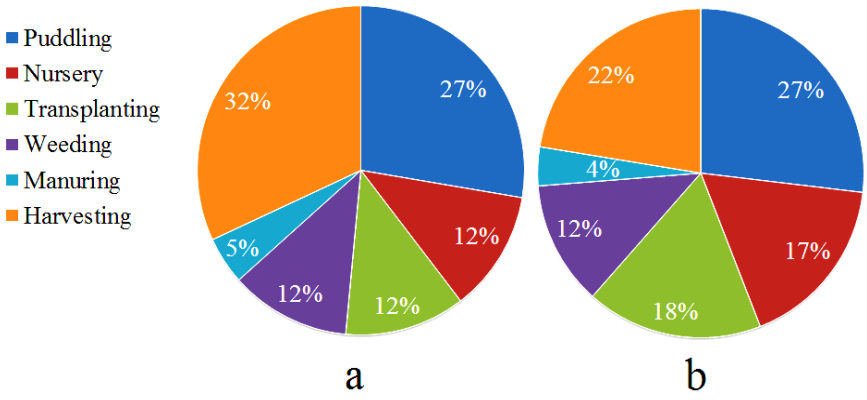

Fig 2: Pie-chart depicting average time investment on different management activities under (a) permanent wet terrace rice cultivation and (b) temporary wet terrace rice cultivation.

Table 1: The *p*-value for one-way ANOVA and mean comparison on farm size, seeding rate, and time spent on farm management, planting density, organic manure use, terrace width, water height and rice yield between Jakhama, Mima and Meriema villages.

Location	Area of farm	Seeding rate	Time spent	Planting density	Manure use	Terrace width	Water height	Rice yield
p-value	*0.15*^{ns}	0.19^{ns}	0.03*	0.10^{ns}	<0.001*	0.03*	<0.001*	0.93^{ns}
	ha	kg ha^{-1}	hr	plant m^{-2}	kg ha^{-1}	cm	cm	Mg ha^{-1}
Jakhama	0.13 a	114 a	443 a	74 a	921 a	816 a	6.5 a	2.69 a
Mima	0.09 a	64 a	217 b	101 a	139 b	613 ab	4.42 ab	2.57 a
Meriema	0.22 a	121 a	323 ab	85 a	244 b	267 b	2.94 b	2.87 a

^{ns}not significant; *significant at $P \leq 0.05$. [1]Within a column, treatment means followed by different lowercase letter are statistically significant at $P \leq 0.05$.

availability of water and soil type among the villages may have resulted in slight variation in yield. More detailed study is needed to have a better understanding of the various management methods to improve the existing management practices.

Farm size and water management

The average farm size of 0.15 ha (Table 1) found in this study was greater than the average range of 0.2-0.5 ha previously reported for a typical Naga field (Kithan, 2014). However, when compared to the national level of approximate land holding of 1.37 ha per farmer (Dev, 2012), the farm size in these study locations is much smaller. Several factors including economic condition of the farmers, land ownership of the farmers, family size and employment status of the farming family may likely contribute to decision on the farm size. Interviews with the farmers showed that the average active farmers per household were five, four and three respectively in Jakhama, Meriema and Mima villages. According to the 2011 population census of Kohima district, out of 2,67,988 individuals, 57% were employed or engaged in secondary or tertiary activities and about 39% were cultivators who are solely reliant on farming for livelihood (Directorate of Economics and Statistics, 2011). The avenues for employment in other sectors might be a reason for the low number of farmers and also subsequently, a smaller farm size since there is less number of cultivators.

Water depth is an important parameter for prediction of rice growth (Talpur *et al*., 2013). The average water height of Jakhama, Mima and Meriema were 6.5, 4.42, and 2.94 cm respectively, which were measured toward the end of mid stage of paddy (Table 1). When compared to a study made by Talpur *et al*., (2013) the optimum water level was 5 cm from transplanting to mid-stage and 10 cm from late mid to harvesting stage for maximum yield. It is evident that the water depths of all the three villages were very low during the late mid-stage and this might have contributed to the low yield observed from this study. This is supported by a finding that variations in timing and quantity of water largely contribute to the differences in annual yield of rice (Ghinasi *et al*., 2007). Therefore, it is certain that there is limited familiarity among the farmers with the maintenance of water height during different stages of cultivation and this is necessary for enhanced production of rice.

Crop management

The average planting density of 87 plants m^{-2} (Table 1) in this study was within the range but lower than the maximum recommended density, 200 plants m^{-2} for optimum rice production (Wang *et al*., 2010). Rice grain yield does not decline until plant populations go below 40 plants m^{-2} (Dunn *et al*., 2016) and therefore, the plant density in these locations may not have reduced the yield below the economic optimum. However, there is potential to increase grain yield by adopting higher planting density in favourable flooded

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paddy fields (Hayashi *et al*., 2006). Jakhama and Meriema had a plant spacing of approximately 15 x 15 cm^2. Mima had a closer spacing of 10 x 10 cm^2 which might have caused mutual shading and led to intra specific competition (Dejen, 2018) that may have lowered the grain yield. Studies conducted by Ezung *et al*. (2005) and Dejen (2018) on the effect of plant spacing observed that the highest yield was obtained with spacing of 20 x 20 cm^2 for better development of panicle, spikelet number and filled grains. The plants grown under wider spacing have more area to draw nutrition from and have more solar radiation which improved the photosynthetic process and hence yields better (Baloch *et al*., 2002). The average seeding rate in this study location was 100 kg ha^{-1} (Table 1) which was lesser than the recommended rate of 150 kg ha^{-1} for any variety or sowing method given by Dunn *et al.* (2016). The lower seeding rate than the recommended rate may have influenced the yield as this study found to explain 60% of the variability in yield by the differences in seeding rate. A lack of improved technical knowledge for crop management was observed among the farmers through this study. In order to provide efficient technical support it is necessary to conduct intensive research to determine optimum plant density, spacing, and seeding rate using the available landraces and other improved varieties in the current agricultural system.

Time investment on different cultivation stage

Time investment in cultivation involves all the activities from puddling the field, forming a nursery for raising the seedlings, transplanting the seedlings, weeding, manuring (green manure, FYM), harvesting and threshing. Across management activities, the time investment among the three villages was significant with $P = 0.03$ (Table 1). The average time investment in Jakhama (443 hrs) was more than Mima village (217 hrs) and statistically similar with Meriema (323 hrs). Out of the ten fields studied in Jakhama, 8 fields were temporary wet which suggests that it must have taken more time and labour at the time of puddling since the soil would have been dry and hard to plough as compared to the puddling of permanent wet terraces where soil is soft and take lesser work hours. Land preparation for rice cultivation starts with puddling of the fields which comprises of repeated ploughing, harrowing and finally leveling which results in homogenization of the soil by breaking soil macro aggregates; controls weeds and facilitates transplanting (Lennartz *et al*., 2008). Across the three villages, the management activities were significantly different with $P < 0.001$ (Table 2). Puddling took much more time (147 hrs) followed by harvesting (116 hrs), nursery (80 hrs), transplanting (76 hrs), weeding (55 hrs) and manuring (18 hrs). More time investment for puddling and harvesting was likely because a lot of physical labour and time is required for these activities. Factors like gender differences, types of tools, climate and other field activities might explain the differences of time investment in different farm activities which were not evaluated in this study. Use of tools and other mechanized implements such as power tillers are recommended to reduce time consumption.

Nutrient Management

Through interview with the farmers, it was observed that the rate of application of manure depends on the availability of manure source. Use of artificial fertilizer was not observed in this study sites. Jakhama village showed the highest rate of manure application likely because of more availability of manure compared to the other two villages. Most of the farmers concurred that they use FYM such as pig and cow manures and green manures because it is cheap and easily available and do not harm the environment. Additionally, it is very useful to improve the soil fertility. There was significant difference ($P < 0.001$) in nutrient application among the three villages (Table 1). In Jakhama, the average manure application, 921 kg ha^{-1} was more than Mima with 139 kg ha^{-1} and Meriema with 244 kg ha^{-1}. According to some farmers who did not use manure, they assumed the soil to be fertile for rice growth and had been experiencing good rice yield and therefore did not feel the need to use it. Few farmers did not have access to either FYM or other fertilizers and therefore, did not apply. Interestingly, the yield did not differ with types of manure application (Table 2). Averaged rice yield across types of manure

Table 2. The *p*-value for one-way ANOVA and mean comparison of time investment on management activities and rice yield response to types of manure application, across the villages. The *p*-value for independent *t*-test and mean comparison of rice yield between manure application and non-application, across the villages.

Management activity	Time		Manure type	Yield	Manure use	Yield
	p-value	<0.001*		0.235[ns]		0.007*
		hr		Mg ha^{-1}		Mg ha^{-1}
Puddling		147.35 a[1]	Ash[2]	3.08	Application	2.99 a
Nursery		79.8 b	AshC[2]	5.06	Non-application	1.86 b
Transplanting		75.95 b	C	2.74 a		
Weeding		55.3 b	CP	2.96 a		
Manuring		17.85 b	None	1.86 a		
Harvesting		115.85 ab				

* significant at $P \leq 0.05$; [ns] not significant ; [1]Within a column, treatment means followed by different lowercase letters are statistically significant at $P \leq 0.05$; [2] this variables were not included in the analysis as it had only single replication; C, cow manure; P, pig manure; AshC, ash and cow manure; CP, cow and pig manure.

was 2.52 Mg ha^{-1}. This might be because of the amount or timing of manure application, soil conditions and technique of water management. Comparison between manure application and non-application showed 61% increase in rice yield with manure application (Table 2). This indicates that the nutrient management can be a major factor influencing rice production with a greater yield benefit. Previous study also reported that application of 10 t ha^{-1} FYM significantly improved number of tillers, number of filled grains and grain yield of rice by 25% over no manure application (Satyanarayana *et al*., 2002).

According to most of the farmers of Jakhama and Meriema village, the urine and dung of the reared pigs and cows are carried through water from terrace to terrace with attached bamboo pipes or drains. Some rear them in their respective homes in their villages and bring sacks of dung, scatter them over the field and puddled for uniform distribution. Also, wood ash which is the residue left from the combustion of wood was also applied in fields to improve the quality of the soil. The average pH of the soils were 5.2, 5.5 and 5.1 for Jakhama, Mima and Meriema, respectively, which were not extremely acidic to largely affect the phosphate availability and rice yield, as the optimum pH at which phosphate availability decreases is 3.76 or lower (Wiklund, 2017). However, the application of lime was not recorded by any of the farmers. In some fields, legumes such as common beans that can fix nitrogen (Wiklund, 2017) were also planted as mixed cropping with rice either in the terraces or bunds which also provide food for the family and fodder for their livestock. The common legumes can fix 37-167 kg N ha^{-1} (Reddy, 2002). In many fields of the three villages, *Azolla* was also seen abundantly both in temporary and permanent WTRC. The presence of *Azolla* may be another good reason that substitutes the use of synthetic nitrogen fertilizer for good rice yield in all the three villages when compared to the national average. In this study, it was observed that nutrient management has a great impact on yield and the use of fertilizers and manures significantly increased yield. Soil testing is required in order to determine the soil nutrient content and determine deficiencies that need to be remedied so that it does not exceed more than what is required by the plants (Ilagan *et al*., 2014). Leaching is a common occurrence in transplanted fields of Kohima and the irrigation schedule should be maintained in order to avoid excessive flooding which can minimise the loss of nutrients (Singh and Jamir, 2017). Soil health can be greatly improved with integrated nutrient management

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including organic, inorganic and bio-fertilisers and increasing the crop productivity, minimising the use of synthetic fertilisers (Das *et al*., 2017). This study found that there is little knowledge of manure management among the farming communities and insufficient literature for information of nutrient management in terrace farming of Nagaland. Thus, more thorough research on nutrient management in terrace system can help provide technical assistance to farmers for improved nutrient management which can increase rice yield.

Conclusion

This study was a single year multiple location evaluation of WTRC in three villages of Kohima district. The results from this study indicate that despite the differences in management practices, the rice yield was not significantly different among the three villages. Although, time investment in farm management was more in Jakhama, it did not contribute to greater yield. Manure application, however, was a contributing factor for increased rice yield. Since labour is becoming limited and expensive, and time investment is becoming costlier, a better approach to nutrient management and implementation of effective tool and improved management techniques that can reduce time and labour cost may help improve the farm management. Further research focused to identify best management practice in WTRC may enhance rice production in such systems.

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References

Bakar, B., Rahman, M. S., Teoh, C. C., Abdullah, M. Z. K. and Ismail, R. (2018). Ambit determination method in estimating rice plant population density. *Food research*. **2(2)**: 177-182.

Baloch, A. W., Soomro, A. M., Javed, M. A., Ahmed, M., Bughio, H. R., Bughio, M. S. and Mastoi, N. N. (2002). Optimum plant density for high yield in rice (*Oryza sativa L*.) *Asian J of plant sciences*. **1(1)**: 25-27.

Das, A., Devi, M. T., Babu, S., and Krishnappa, R. (2017). Integrated nutrient management in rice. *Agri world*. 30-36.

Dejen, T. (2018). Effect of plant spacing and number of seedlings per hill to transplanted rice (*Oryza sativa* x *Oryza glaberrima*) under irrigation in Middle Awash, Ethopia. *J of applied life sciences international*. **17(4)**: 1-9.

Department of Agriculture, Government of Nagaland. (2012). Vision 2025- Food for all.

Dev, M. (2012). Small farmers in India: Challenges and opportunities. *IGIDR*. 1-35.

Dinesh, D., Baskar, A. and Ammal, U. B. (2005). Influence of methods of rice cultivation on the yield, nutrient availability and uptake of nutrients in the coastal soils of Karaikal. *J of rice research*. **2(1)**: 56-60.

Directorate of Economics and Statistics. (2011). Nagaland statistical handbook, Govt. of Nagaland.

Directorate of Economics and Statistics. (2018). Nagaland statistical handbook, Govt. of Nagaland.

Directorate of Economics and Statistics. (2019). Nagaland statistical handbook, Govt. of Nagaland.

Dunn, B.W. (2016). Rice plant population guidelines. Dept. of primary industries. **(1)**. 1-2.

Ezung, K., Singh, M. and Ahmed, P. (2005). Effect of nitrogen levels and spacing on growth, yield attributes and yield of upland rice (*Oryza sativa*) under terrace cultivation in Nagaland. *Agronomy digest*. **5**: 1-2.

Gadal, N. and Shrestha, J. (2019). A review on production status and growing environments of rice in Nepal and in the world. *Archives of Agri and Env Sci*. **4(1)**: 83-87.

Ghinassi, G. (2007). Guidelines for crop production under water limiting conditions, contribution from ITAL-ICID, member of the WG-IADWS, Italy.

Hayashi, S., Kamoshita, A. and Yamagishi, J. (2006). Effect of planting density on grain yield and water productivity of rice (*Oryza sativa* L.) grown in flooded and non-

flooded fields in Japan. *Plant production science*. **9(3)**: 298-311.

Illagan, L. A., Tablizo, R. P., Barba, R. B. and Marquez, N. A. (2014). Soil fertility evaluation for rice production in Catanduanes Province, Phillipines. *Int. J of Scientific and technology research*. **3(12)**: 81-87.

Jajuo, K. (2013). Traditional significance of paddy cultivation for Mao Naga farmers in Manipur. *J of business management and social sciences research*. **2(10)**: 33-39.

Kithan, L. (2014). Indigenous system of paddy cultivation in terrace and jhum fields among the nagas of Nagaland. *International J of Scientific and Research Publications*. **4(3)**: 1-4.

Kumar, M., Chowdhury, P., Kumar, R. and Ray, S. K. (2016). System of rice intensification (SRI) - An option for enhancement water productivity in agriculture. *ICAR*. 116-120.

Lennartz, B., Horn, R., Duttmann, R., Gerke, H. H., Tippkotter, R., Eickhorst, T., Janssen, I., Janssen, M., Ruth, B., Sander, T., Shi, X., Sumfleth, K., Taubner, H. and Zhang, B. (2008). Ecological safe management of terraced rice paddy landscapes. *Soil Tillage Res*. 1-14.

Li, T., Bouman, B., and Boling, A. (2009). Calibration and validation: Experimental data collection and analysis- Standard procedure for determining yield components at harvest. Geo-spatial Science and Modeling Cluster Sustainable Impact Platform IRRI, Metro Manila, Philippines. https://sites.google.com/a/irri.org/oryza2000/calibration-and-validation (accessed on 5/14/2021)

Rahman, M. A., Kang, A., Nagabhatla, N. and Macnee, R. (2017). Impacts of temperature and rainfall variation on rice productivity in major ecosytems of Bangladesh. *Agri and food secure*. **6(10)**: 1-11.

Rao, M. V. (1969). A few guidelines for rice cultivation. *Oryza*. **6**: 35-36.

Reddy, P., Ladha, J. K. and James, E. K. (2002). Nitrogen fixation in rice. In: Nitrogen Fixation at the Millenium. Ed. Leigh, G. J. Elsevier, Amsterdam, The Netherlands. 421-445.

Reddy, S. R. (2009). Agronomy of field crops. 3rd ed. Ludhiana: Kalyani Publishers. 7-124.

Reddy, S. R. and Hukkeri, S. B. (1980). Increasing effectiveness of fertilisers through weed control in direct seeded irrigation rice. *Fert News*. **25**: 30-33.

Saikai, T. N., Borah, D. and Borah, R. (2008). Terrace cultivation and its impact in North-East India. In: Deshpande R. S, Sharma V. P, Malik R. P. S, Jha B, Ansari S. A, editors. Glimpses of Indian agriculture. 2nd ed. New Delhi: Academic foundation. 149-160.

Satyanarayana, V., Vara Prasad, P. V., Murthy, V. R. K. and Boote, K. J. (2002). Influence of integrated use of farmyard manure and inorganic fertilizers on yield and yield components of irrigated lowland rice. *J of plant nutrition*. **25(10)**: 2081-2090.

Singh, C., Singh, P. and Singh, R. (2009). Modern techniques of raising field crops. 2nd ed. New Delhi: Oxford and IBH Publishing Company Pvt. Ltd. 3-54.

Singh, P. K. and Jamir, A. (2017). Comparative study of soil fertility status of direct seeded and transplanted rice under kohima district of Nagaland. *J of Pharmacognosy and Phytochemistry*. 64-68.

Talpur, M. A., Changying, J., Junejo, S. A., Tagar, A. A. and Ram, B. K. (2013). Effect of different water depths on growth and yield of rice crop. *AJAR*. **8(37)**: 4654-465.

Uphoff, N. (2006). Report on a visit to Vietnam to review SRI progress, January 3-12. Cornell International Institute for food, agriculture and development, Ithaca, NY. http://ciifad.cornell.edu/sri/countries/vietnam/vnntutr106.pdf (accessed on 4-8-2020).

Wiklund, J. (2017). Effects of wood ash on soil fertility and plant performance in Southwestern Kenya. *Dept. of soil and Env*. 12-13.

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MOSSES OF PHEK DISTRICT, NAGALAND, INDIA

Double Reviewed

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Abstract: The present study on the moss flora of Phek District, Nagaland reveals the presence of a rich diversity of mosses. Thirty one species of mosses belonging to 25 genera, 15 family and 8 order were collected from Phek District, Nagaland. On investigation of the collected specimens, five species were found new to Eastern Himalayas viz. *Taxiphyllum giraldii* (C. Muell.) M. Fleisch., *Meteoriopsis ancistrodes* (Ren. & Card.) Broth., *Duthiella declinata* (Mitt.) Zanten., *Bartramidula roylei* (Hook.f.) Bruch & Schimp. and *Weissia controversa* Hedw. 18 species were found to be new to the Moss Flora of Nagaland. All mosses from Phek District, Nagaland have been collected and studied for the first time.

Keywords: Musci, Phek District, Nagaland.

Introduction

Nagaland is located in the North Eastern region of India bordered by the state of Assam in the west, Arunachal Pradesh and part of Assam in the north, Burma in the east and Manipur in the south. Nagaland has a total area of 16,579 square kilometers where twenty percent (20 %) of the total land area of the State is covered with the evergreen tropical and sub tropical forest. Some parts of the forest regions are accessible to the people while the interiors are impenetrable and home to wild animals. Due to Jhum cultivation, the forests of Nagaland are being exploited leading to gradual depletion of the flora and fauna.

Phek is one of the district in the state of Nagaland. It lies in the South-Eastern part of Nagaland, bounded by Myanmar in the east, Zunheboto and Kiphire in the North, Manipur in the South and Kohima in the West. It has an area of about 2,026 square kilometer. Phek District lies at the lowest altitude at 1,524 m above sea level and the village of Pfutsero town at the highest point of 2,136 m above sea level.

In the field of study of Moss Flora of Nagaland, the only work recorded was by Gangulee (1969 – 80) in "Mosses of Eastern India and Adjacent Regions" where he described some of the Moss taxa to be found in Naga Hills but no localities were specified. The other record on Mosses of Nagaland is an abstract by Lal *et al.* (2003) on new distributional records of a rare and endemic moss *Fabronia assamica* Dix. (Fabroniaceae) from Nagaland. Bansal *et al.* (2010) published a paper on Morpho-taxonomic study on the genus *Brachymenium* Schwaegr. from Nagaland (North-Eastern Hills), India. Another record is on the Ph.D. thesis "Studies on Mosses of Mokokchung and Kohima Districts, Nagaland. 2012" by Vaphuno Sale (2012.) Chaturvedi *et al.* (2011) also published papers on Morpho-Taxonomic study of some corticolous Mosses of Longkhum Reserve Forest, Mokokchung District, Nagaland and on Diversity of Genus *Fissidens* Hedw. (Musci) of Kohima District, Nagaland. In the context of bryological point of view Nagaland is rather unexplored as there is no comprehensive account on mosses of Nagaland.

Materials and Methods

The specimens have been collected from different localities under Phek District, Nagaland. The collection was done in the year 2018 and 2019. Field pictures were taken with the help of Canon camera EOS 1100D. The fresh specimens collected from the natural habitats were spread between sheets of blotting papers and made to absorb off the moisture. After drying, the specimens were put in small paper packs and then kept in brown paper herbarium packets mentioning the important details on the herbarium labels (Specimen number, date, name of locality, collector's name, specimen name and family). For the study, the plant materials were soaked in water for few

hours for proper stretching of the specimen and mounted in plain water for quick examination or observation. Observations and photographs of the specimens were carried out with the help of Coslab trinocular microscope and Vision USB camera.

Results and Discussion

Atrichum longifolium Card. & Dix. ex Gangulee.

Plants large, soft, yellowish green. Stems simple or branched, up to 6 cm tall. Leaves laxly arranged on the stem, curled and twisted when dry. Leaves narrow lingulate, non-sheathing, about 1.5 cm long. Leaf margin formed with elongated cartilaginous cells developing sharp double teeth. Costa prominent, toothed on tip back, ends in spines at the leaf apex. Upper leaf cells rounded quadrate or hexagonal, lower leaf cells rectangular and thick walled.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1001 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing in the soil.
Range: Eastern Himalayas.

Campylopus flexuosus (Hedw.) Brid. in Mant. Musc., 4 : 71 (1819)

Plants green to olive green green in dense tufts, size varies from 1-10 cm, branched. Leaves erect to erectopatent, flexuose when dry, lanceolate-subulate, about 5-6 mm long, wider base narrowing into a canaliculated subula with incurved margins. Leaf tip margin serrated, costa occupying about half of the leaf base. Upper leaf cells short rectangular, lower leaf cells long rectangular becoming narrower near margin. Alar brown in colour, bulging, formed by large inflated cells.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1004 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing on dead tree logs.
Range: Eastern Himalayas.

Campylopus introflexus (Hedw.) Brid. in Mant. Musci.: 72 (1819)

Plants dark green, caespitose, about 2cm high, branching present. Leaves erect to erectopatent, not much change when dry. Leaves lanceolate subulate, about 3 mm long, red rhizoids present on the leaf base of older leaves. Leaf tip denticulated and leaf margins incurved. Costa covers almost half of the leaf base. Upper leaf cells rhomboid, mildly incrassate, lower leaf cells rectangular becoming narrower towards the margin. Alar not bulging, formed by pale cells which becomes coloured in older leaves.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1007 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing decaying tree logs.
Range: Eastern Himalayas, South India.

Syrrhopodon gardneri (Hook.) Schwaegr. in Sp. Musc. Suppl. 2(1): 110 (1824)

Plants dull green, tufted, branching present, about 1 cm high. Leaves erectopatent, curled when dry, lingulate, about 3 mm long. Leaf tip acute, leaf margin serrated from apex till base. Costa ending just few cells below the leaf apex with some few spines. Leaf cells chlorophyllose, ovate-quadrate, papillose, obscure. Cancellinae of about 5 to 10 rows of large hyaline rectangular cells, 3 to 6 rows of narrow rectangular cells towards the margin which rounds off on top.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1005 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing on the tree, in association with *Sematophyllum caespitosum*.
Range: Eastern Himalayas, Western Himalayas, South India.

Hyophila involuta (Hook.) Jaeg., Ber. S. Gall. Naturw. Ges. 1871 – 1872 : 354. 1873.

Plants dark green in colour, top of the plant in a rosette form, densely tufted, about 1 cm long. Leaves oblong-lingulate, about 3 mm long, leaf base sheathing, leaf margin smooth, minutely serrulated at the leaf apex, leaf margin inrolled when dry but flat when moist. Costa single, percurrent. Upper leaf cells chlorophyllose, mamillose, obscure, round-

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quadrate, few large cells towards the margin. Lower leaf cells rectangular, hyaline, smooth.
Distribution and Ecology : Nagaland, Phek District, Zapami, 1020 Vap Phek, at an altitude of 156 meters above sea level, habitat – found growing on the guard walls.
Range: Eastern Himalayas, Western Himalayas, Rajasthan, South India, Central India, Gangetic Plain.

Bryoerythrophyllum yunnanense (Herz.) Chen., Hedwigia 80: 5. 259. 52 f. 3-5. 1941.

Plants reddish brown in colour, branching present, caespitose, about 1.5 cm high. Leaves lanceolate, erectopatent, curled when dry, about 3 mm long, leaf base half-sheathing, leaf apex acute, leaf margin involute at the leaf base, leaf margin serrulated at the leaf tip. Costa single, narrow, percurrent. Upper leaf cells round-quadrate, multipapillose. Lower leaf cells rectangular, hyaline.
Distribution and Ecology : Nagaland, Phek District, Lekromi, 1031 Vap Phek, at an altitude of 2050 m above sea level, habitat – found growing in the soil.
Range: Western Himalayas, Eastern Himalayas.

Weissia controversa Hedw., Spec. Musc., 67. 1801; Saito, J. Hattori Bot. Lab., 39: 426. 1975. (Figure 1: A & B)

Plants green in colour, densely tufted, about 6 mm long. Leaves linear-lanceolate, curled when dry, erect-spreading when wet, about 2.5 mm long, leaf base slightly sheathing, leaf apex acute, leaf margin incurved, crenulated leaf margin at the upper part of the leaf due to the presence of papillae. Costa single, excurrent into an apiculus. Upper leaf cells chlorophyllose, papillose, obscure, round-quadrate, lower leaf cells rectangular, hyaline, smooth, incrassate, a little shorter towards the margin.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1013 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing in the soil, in association with *Pseudosymblepharis khasianus*.
Range: Western Himalayas, South India.

Leptodontium handelii Ther. in Ann. Crypt. Exot., 5 : 171 (1932)

Plants slender, yellowish green, caespitose, sometimes branching present with proliferation, up to 2 cm tall. Leaves erectopatent to spreading, appressed to the stem when dry, lingulate to ovate, about 1.5 mm long. Leaf apex acute, leaf margin inrolled in the lower half, leaf margin serrated in the apical portion of the leaf, costa vanishing below leaf tip. Upper leaf cells round, papillose, incrassate, becoming rectangular below. Lower leaf cells smooth, rectangular, becoming short rectangular or quadrate towards the margin.
Distribution and Ecology : Nagaland, Phek District, Lekromi, 1030 Vap Phek, at an altitude of 2050 m above sea level, habitat – found growing in the rocky soil.
Range: Eastern Himalayas.

Funaria hygrometrica Hedw., Spec. Musc. 172. 1801.

Plants green in colour, branching present, about 1 cm long. Leaves oblong-lanceolate, erect-spreading when moist, shrunk when dry, clustered to form a rosette at the top, about 4 mm long, leaf apex acute, leaf margin entire and flat. Marginal cells narrow and elongated forming a border and fine dentation at the tip of the leaf. Costa single, percurrent or short excurrent. Upper leaf cells sub-hexagonal, thin-walled. Lower leaf cells sub-hexagonal, thin-walled.
Distribution and Ecology : Nagaland, Phek District, Kami & Zapami, 1016 Vap Phek, 1017 Vap Phek, 1022 Vap Phek, at an altitude of 156 meters above sea level, habitat – found growing in the soil, in association with *Bryum argenteum* and *Philonotis fontana*.
Range: Eastern Himalayas, Western Himalayas, South India, Central India, Gangetic plains.

Mniobryum ludwigii (Schwaegr.) Loesk., Stud. Morph. Syst. Laubm. : 124. 1910.

Plants green in colour, tufted, erect, branching may be absent or present, about 2.3 cm long, stems red in colour. Leaves broad,

ovate-lanceolate, erect to erectopatent when moist, flexuose when dry, about 1.3 mm long, costa decurrent, leaf apex acute, leaf margin flat, leaf margin serrulated at the tip of the leaf. Costa single, ending little below the leaf tip. Upper leaf cells rhomboid-hexagonal and narrow towards the margin at the mid-leaf region. Lower leaf cells rectangular, narrower towards the margin.
Distribution and Ecology : Nagaland, Phek District, Zapami, 1021 Vap Phek, at an altitude of 156 meters above sea level, habitat – found growing in the soil, in association with *Funaria hygrometrica* and *Philonotis*.
Range: Western Himalayas, Eastern Himalayas.

Brachymenium longicolle Ther. in Bull. Soc. Bot. Geneva, 26: 85 (1936)

Plants greenish in colour, sub-floral innovations present, densely tufted, about 1 cm long. Leaves oblong-spathulate, erectopatent when moist, contorted when dry, about 2.5 mm long, leaf apex acuminate, leaf margin revolute at the leaf base, serrulated at the upper part of the leaf. Costa single, excurrent into an arista. Cells at the basal portion of the leaf rectangular, three rows of shorter, smaller, rectangular cells forming a border. Cells at the middle portion of the leaf rhomboid, thin-walled, two rows of narrow linear elongated cells forming a clear border. Cells at the apical portion of the leaf rhomboid, thin-walled, one row of narrow linear elongated cells forms a clear border at the leaf margin.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1008 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing on the tree.
Range: Eastern Himalayas.

Anomobryum filiforme var. concinnatum (Spruce) Loesk. (Asthana & Sahu, 2013);

Plants slender, green in colour, densely tufted, julaceous, about 9mm long. Leaves imbricate, concave, oblong-ovate, about 1 mm long, leaf apex acute, leaf margin flat and entire, costa reaches the leaf apex. Upper leaf cells thin-walled, narrow elongated. Lower leaf cells sub-rectangular, becoming shorter at the extreme base.
Distribution and Ecology : Nagaland, Phek District, Kami, 1019 Vap Phek, at an altitude of 156 meters above sea level, habitat – found growing in the soil in association with *Philonotis fontana*.
Range: Western Himalayas, Eastern Himalayas, South India.

Bryum argenteum Hedw., Spec. Musc. 181. 1801.

Plants silver green in colour, tufted, julaceous, about 1.5 cm high. Leaves concave, broadly ovate, densely arranged on the stem, erectopatent, about 1 mm long, leaf apex acuminate, leaf margin flat and entire. Costa single, excurrent ending into a hyaline arista. Upper leaf cells hyaline, rhomboidal, narrow and lower leaf cells chlorophyllose.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1010 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing in the soil.
Range: Western Himalayas, Eastern Himalayas, South India, Central India, Rajasthan.

Bryum alpinum Huds. *ex* With., Syst. Arr. Brit. Pl. ed. 4, 3: 824. 1801.

Plants reddish brown in colour, erect, branching present, sub-floral innovations present, about 9 mm high. Leaves lanceolate, erect to erectopatent, not changed when dry, about 2 mm long, leaf apex acuminate, leaf margin entire and reflexed. Costa single, excurrent into an arista. Upper leaf cells linear rhomboid, narrower towards the leaf margin but not forming a distinct border. Lower leaf cells rectangular, thick-walled.
Distribution and Ecology : Nagaland, Phek District, Lekromi, 1035 Vap Phek, at an altitude of 2050 m above sea level, habitat – found growing in the soil.
Range**:** Western Himalayas, Eastern Himalayas, South India.

Bartramidula roylei (Hook.f.) Bruch & Schimp. in Bryol. Eur., 4: 55 (1846)
(Figure 2: A, B & C)

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Plants small and slender, caespitose, green in colour, about 5mm high, subfloral innovations present, tomentose below. Leaves erect, lanceolate, acuminate, about 1mm long, leaf margin flat, leaf margin serrulated in the upper half of the leaf. Costa excurrent in to an arista. Leaf cells thin walled, rectangular, papillose, narrower at the apex and broader at the base.
Distribution and Ecology : Nagaland, Phek District, Zapami, 1023 Vap Phek, at an altitude of 156 meters above sea level, habitat – found growing in the soil.
Range: Western Himalayas, Central India, Gangetic plains, South India.

Philonotis fontana (Hedw.) Brid. in Bryol. Univ., 2 : 18 (1827)

Plants slender, yellowish green in colour, extensively tufted with tomenta below, about 2 cm high. Leaves ovate lanceolate, acuminate, imbricately arranged around the stem, appressed to the stem when dry, about 1.5 mm long, leaf margin dentate, revolute in the lower half of the leaf. Costa excurrent in to an arista. Upper leaf cells narrow, linear, incrassate, mamillose. Lower leaf cells rectangular, mamillose.
Distribution and Ecology : Nagaland, Phek District, Kami & Lekromi, 1018 Vap Phek, 1028 Vap Phek, at an altitude of 2050 m above sea level, habitat – found growing in the soil, in association with *Anomobryum concinnatum*.
Range: Eastern Himalayas, Western Himalayas, South India.

Philonotis thwaitesii Mitt. in Musci Ind. Or. : 60 (1859)

Plants yellowish green in colour, with brown tomenta below, subfloral innovations present, about 1 cm high. Leaves erect, triangular to linear lanceolate, about 2 mm long, leaf apex acuminate, leaf margin denticulate. Costa excurrent in to an arista. Upper leaf cells Linear elongate, papillose, obscure. Lower leaf cells rectangular, less papillose, becoming quadrate at the extreme base.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1015 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing in the soil, in association with *Bryum argenteum*.
Range: Eastern Himalayas, Central India, Western Himalayas, South India.

Duthiella declinata (Mitt.) Zanten. in Blumea, 9 : (1959)
(Figure 3: A & B)

Plants are yellowish to brownish green in colour, irregularly pinnately branched. Leaves dense, complanately arranged, erect, spreading when dry and wet, lanceolate, about 2.5 mm long. Leaf apex acuminate, leaf margin denticulate almost to the base, flat, costa single and ending below the leaf tip. Upper leaf cells thick-walled, rhomboidal-hexagonal, single papilla present in the mid-leaf cells, single row of spine smooth cells forms the leaf margin. Lower leaf cells thin-walled, smooth, irregularly elongated, sinuose. Alar distinct with some quadrate cells.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1009 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing on the tree.
Range: Western Himalayas.

Meteorium buchananii (Brid.) Broth. Nat. Pfl. 1 (3): 818. (1906)

Plants green in colour, branching present, secondary shoots hangs down from the trees, robust. Leaves concave, plicate, oblong-ovate, dense, imbricate, erect, about 4 mm long, leaf base auricled, leaf apex rounded, suddenly narrowed into a long subula, leaf margin minutely crenulated. Costa single, not reaching the leaf apex. Leaf margin bordered by some linear rhomboidal smooth cells. Leaf cells at the subula linear or narrow rhomboid, smooth, cells at the upper portion of the leaf rhomboid, unipapillate, leaf cells at the juxta-costal region of the extreme leaf base rectangular, smooth, porose walls.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1001 Vap Phek, at an altitude

of 2133 m above sea level, habitat – found growing on the tree, in association with *Macrothamnium macrocarpum*.
Range: Eastern Himalayas, Western Himalayas, South India.

Floribundaria floribunda (Doz. & Molk.) M. Fleisch. in Hedwigia, 44: 302 (1905)

Plants yellowish green in colour, found in dense masses, pinnately branched. Leaves arranged in feather-like pattern, wide spreading, lanceolate, about 1.5 mm long, leaf base wide, leaf apex narrow acuminate which is drawn into a long point, leaf margin lightly serrated. Costa single, covering about half of the leaf length. Leaf cells narrow, linear, elongated with a row of papillae on the lumen, alar cells not so distict, basal cells wider and smooth.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1003 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing on the tree.
Range: Western Himalayas, Eastern Himalayas, South India.

Meteoriopsis ancistrodes (Ren. & Card.) Broth. (Asthana & Sahu, 2013)
(Figure 4: A & B)

Plants yellowish green in colour, branching present, secondary branches pendulous. Leaves dense, ovate-lanceolatre, usually caniculated, folded here and there, about 2 mm long, leaf tip narrows into an arista, leaf margin denticulate at the tip. Costa single, vanishes at the midleaf. Leaf cells thick-walled, linear-rhomboidal, papillose, cells at the auricular region hyaline and rectangular.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1012 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing in the rocky soil.
Range: Western Himalayas.

Thuidium meyenianum (Hamp.) Doz. & Molk. in Bryol. Jav., 2: 121 (1865)

Plants yellowish green in colour, wiry, dense, branching present. Leaves dimorphic. Stem leaves suddenly narrowed into a long acumen from cordate base, plicate, about 0.7 mm long. Branch leaves smaller than the stem leaves, erect-spreading, curled/appressed when dry, concave-ovate, about 0.1 mm long, leaf tip acute, leaf margin crenulate and flat. Costa single, ending below leaf apex. Leaf cells small, irregularly hexagonal, obscure, papillose.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1011 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing on the rock.
Range: Western Himalayas, Eastern Himalayas, South India.

Thuidium cymbifolium (Doz. *et* Molk.) Doz. et Molk., Bryol. Jav. 2: 115. 221. 1865.

Plants deep green in colour, robust, dense, main stem creeping, branching present, main stem gives rise to semi-erect secondary branches. Leaves dimorphic. Stem leaves erectopatent, ovate-lanceolate, about 2.5 mm long, leaf apex long acuminate, costa single, excurrent. Branch leaves ovate-lanceolate, erectopatent, concave, about 0.5 mm long, leaf apex acute, leaf margin crenulated, costa single and vanishes below apex. Leaf cells ovate-quadrate, papillose, at the extreme base of leaf attachment area, cells are elongated and smooth.
Distribution and Ecology : Nagaland, Phek District, Lekromi, 1029 Vap Phek, at an altitude of 2050 m above sea level, habitat – found growing in the soil and rock.
Range: Eastern Himalayas, South India, Central India, Western Himalayas.

Eurhynchium swartzii (Turn.) Curn. Bryoth. Eur., 12: 593 (1862)

Plants yellowish green in colour, delicate, in thin mats, branching present. Leaves somewhat complanate, erectopatent to spreading, shrunked but spreading when dry. Leaves ovate, about 1 mm long, leaf tip acuminate-acute, decurrent at the leaf base, leaf margin denticulate almost to the base. Costa covering about three fourth of the leaf length. Upper leaf cells elongate rhomboid, becomes broader lower down. Lower leaf cells rectangular.

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Distribution and Ecology : Nagaland, Phek District, Zapami, 1026 Vap Phek, at an altitude of 156 meters above sea level, habitat – found growing on the rock.
Range: Eastern Himalayas.

Eurhynchium praelongum (Hedw.) Schimp. B.S.G. in Bryol. Eur., 5: 224 (1854)

Plants yellowish green in colour, branching present, main stem creeping. Leaves erectopatent to spreading, shrunked but still spreading when dry. Leaves cordate-lanceolate, about 1 mm long, leaf tip extends in to an apiculus, leaf margin dentate up to the base. Costa covering about ¾ of the leaf length. Leaf cells elongated, narrow rhomboid, cells at the extreme base rectangular.
Distribution and Ecology : Nagaland, Phek District, Zapami, 1025 Vap Phek, at an altitude of 156 meters above sea level, habitat – found growing on the rock.
Range: Western Himalayas, Eastern Himalayas.

Sematophyllum caespitosum (Hedw.) Mitt., J. Linn. Soc. Bot. 12: 479. (1869)

Plants yellowish green in colour, tufted, main stem creeping, branching present, secondary branches ascending. Leaves ovate-lanceolate, concave, erectopatent when moist and appressed to the stem when dry, about 2 mm long, leaf apex narrow acuminate, leaf margin entire. Costa absent. Leaf cells linear, narrow. Alar cells differentiated, reddish or brownish in colour, four large tinted oblong inflated cells, smaller or shorter cells above the tinted cells.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1006 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing on the tree, in association with *Syrrhopodon gardneri*.
Range: Eastern Himalayas, South India.

Taxiphyllum giraldii (C. Muell.) M. Fleisch., Musci Fl. Buitenzorg 4: 1435. 1923.
(Figure 5: A & B)

Plants yellowish in colour, tufted, main stem creeping, branching present, complanate. Leaves ovate-lanceolate, concave, spreading, about 1.3 mm long, leaf apex acuminate, leaf margin denticulate, flat or revolute on one side. Costa double, short, not reaching the middle portion of the leaf. Leaf cells narrow, rhomboid to linear, basal marginal cells rectangular becoming quadrate at the extreme base.
Distribution and Ecology : Nagaland, Phek District, Thetsumi, 1036 Vap Phek, 1037 Vap Phek, at an altitude of 156 meters above sea level, habitat – found growing in the soil.
Range : Western Himalayas.

Hypnum plumaeforme Wils., London J. Bot. 7: 277. 1848.

Plants yellow green in colour, main stem creeping, branching present, tufted. Leaves ovate-lanceolate, concave, dense, erectopatent, falcato-secund, about 1 mm long, leaf apex acute, leaf margin minutely serrated at the leaf tip. Costa double, short, indistinct. Leaf cells linear. Basal cells at the leaf attachment region rectangular and tinted.
Distribution and Ecology : Nagaland, Phek District, Lekromi, 1034 Vap Phek, at an altitude of 2050 m above sea level, habitat – found growing on the rock.
Range: Eastern Himalayas, South India.

Hypnum submolluscum Besch. in Ann. Sc. Nat. Bot. ser. 7, 15: 93 (1892)

Plants yellowish green in colour, branching present, main stem creeping, dense mats. Leaves dense, concave, ovate-lanceolate, falcate, imbricate erectopatent, circinate when dry, about 1 mm long. Leaf apex denticulate and narrow, leaf margin recurved at places. Costa absent or indistinct. Leaf cells elongated, irregular, a row of rectangular cells at the extreme leaf base with some shorter cells above it.
Distribution and Ecology : Nagaland, Phek District, Lekromi, 1033 Vap Phek, at an altitude of 2050 m above sea level, habitat – found growing on the rock.
Range: Eastern Himalayas.

Pseudosymblepharis khasianus (Mitt.) Zander, Bull. Buffalo Soc. Nat. Sc., 32: 80. 1993.

Plants yellowish-green in colour, robust, dense, about 1 cm long. Leaves curled when dry, spreading when moist, laxly arranged on the stem, linear-lanceolate, about 6 mm long, leaf base slightly sheathing, leaf apex acute-acuminate. Costa single, excurrent into a short subula. Upper leaf cells chlorophyllose, papillose, obscure, round-quadrate. Lower leaf cells rectangular, hyaline, smooth, thin-walled, narrower towards the margin, extending up for some distance into an indistinct zone of subrectangular cells having coarser papillae which ultimately merge into the laminar cells.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1014 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing in the soil, in association with *Weissia controversa*.
Range: Eastern Himalayas.

Macrothamnium macrocarpum (Reinw. & Hornsch.) Fleisch. in Hedwigia, 44: 308 (1905)

Plants yellowish green in colour, branching present, main stem wiry, frondose. Leaves cordate, about 1 mm long, leaf apex acute, leaf margin denticulated, costa short double. Leaf cells narrow rhomboid, becomimg broader lower down.
Distribution and Ecology : Nagaland, Phek District, Pfutsero, 1002 Vap Phek, at an altitude of 2133 m above sea level, habitat – found growing on the tree, in association with *Meteorium buchananii*.
Range: Western Himalayas, Eastern Himalayas, South India.

Table 1: Showing the number of Species, Family and Order identified from Phek district, Nagaland.

Sl. No.	Order	Family	Species
1.	Polytrichales	Polytrichaceae	*Atrichum longifolium*
2.	Dicranales	Dicranaceae	*Campylopus flexuosus*
3.			*Campylopus introflexus*
4.	Syrrhopodontales	Calymperaceae	*Syrrhopodon gardneri*
5.	Pottiales	Pottiaceae	*Hyophila involuta*
6.			*Bryoerythrophyllum yunnanense*
7.			*Weissia controversa*
8.			*Leptodontium handelii*
9.	Funariales	Funariaceae	*Funaria hygrometrica*
10.	Eubryales	Bryaceae	*Mniobryum ludwigii*
11.			*Brachymenium longicolle*
12.			*Anomobryum filiforme var. concinnatum*
13.			*Bryum argenteum*
14.			*Bryum alpinum*
15.		Bartramiaceae	*Bartramidula roylei*
16.			*Philonotis thwaitesii*
17.			*Philonotis fontana*
18.	Isobryales	Trachypodaceae	*Duthiella declinata*
19.		Meteoriaceae	*Meteorium buchananii*
20.			*Floribundaria floribunda*
21.			*Meteoriopsis ancistrodes*
22.	Hypnobryales	Thuidiaceae	*Thuidium meyenianum*
23.			*Thuidium cymbifolium*
24.		Brachytheciaceae	*Eurhynchium swartzii*
25.			*Eurhynchium praelongum*
26.		Sematophyllaceae	*Sematophyllum caespitosum*
27.		Pterigyandraceae	*Taxiphyllum giraldii*

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28.		Hypnaceae	*Hypnum plumaeforme*
29.			*Hypnum submolluscum*
30.			*Pseudosymblepharis khasianus*
31.		Hylocomiaceae	*Macrothamnium macrocarpum*

Conclusion

From the present investigation, thirty one species of mosses belonging to 25 genera, 15 family and 8 order (Table 1) from Phek District, Nagaland were identified. *Taxiphyllum giraldii* (C. Muell.) M. Fleisch., *Meteoriopsis ancistrodes* (Ren. & Card.) Broth., *Duthiella declinata* (Mitt.) Zanten., *Bartramidula roylei* (Hook.f.) Bruch & Schimp. and *Weissia controversa* Hedw. were found to be new to the Moss Flora of Eastern Himalayas. Whereas *Atrichum longifolium* Card. & Dix. ex Gangulee., *Campylopus flexuosus* (Hedw.) Brid., *Pseudosymblepharis khasianus* (Mitt.) Zander., *Weissia controversa* Hedw., *Leptodontium handelii* Ther., *Brachymenium longicolle* Ther., *Anomobryum filiforme var. concinnatum* (Spruce) Loesk., *Bartramidula roylei* (Hook.f.) Bruch & Schimp., *Philonotis fontana* (Hedw.) Brid., *Philonotis thwaitesii* Mitt., *Duthiella declinata* (Mitt.) Zanten., *Floribundaria floribunda* (Doz. & Molk.) M. Fleisch., *Meteoriopsis ancistrodes* (Ren. & Card.) Broth., *Thuidium meyenianum* (Hamp.) Doz. & Molk., *Eurhynchium swartzii* (Turn.) Curn., *Eurhynchium praelongum* (Hedw.) Schimp., *Hypnum submolluscum* Besch., *Macrothamnium macrocarpum* (Reinw. & Hornsch.) Fleisch. were found to be new to the Moss Flora of Nagaland. In the recent study, it was found that Phek district, Nagaland has a rich diversity of Moss flora in different habitats viz. soil, rocks and trees. Till date, detailed study on Moss flora of only two districts of Nagaland (Kohima and Mokokchung districts) has been done. Therefore, the recent study result is a good addition to the Moss flora of Nagaland in general.

Acknowledgement

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References

Alam, A. (2015). Moss flora of India. *An updated summary of taxa.* 1–185.

Aziz, M. N. and Vohra, J. N. (2008). Pottiaceae (Musci) of India. Bishen Singh Mahdndra Pal Singh. Dehradun, India. 366.

Bansal, P., Nath, V. and Chaturvedi S. K. (2010). Morphotaxonomic study on the genus *Brachymenium* Schwaegr. from Nagaland (North-Eastern Hills), India. *Phytomorphology*. **60 (3&4):** 150 – 155.

Chaturvedi, S. K., Sale, V. and Eshuo, K. (2011). Morphotaxonomic study on some corticolous mosses of Longkhum reserve forest, Mokokchung district, Nagaland. *Bionature*. **31(1)**: 1–12.

Chaturvedi, S. K., Sale, V. and Eshuo, K. (2011). Diversity of genus *Fissidens* hedw. (Musci) from Kohima district, Nagaland, *Journ. Ind. Bot. Soc*. **90(1&2)**: 372–375.

Chopra, R. S. (1975). Taxonomy of Indian mosses (An introduction). CSIR Publication, New Delhi. 631.

Chopra, R. S. and Kumar, S. S. (1981*).* Mosses of the Western Himalayas and adjacent plains. *Chronica Botanica* Co. New Delhi. 142.

Gangulee, H. C. (1969 – 1980). Mosses of eastern India and adjacent regions. *Fascicles.* Calcutta. 1–8.

Gangulee, H. C. (1986). Handbook of Indian mosses. 4 fig. 50 pl. Balkema Rotterdam. 123.

Lal, J. (2005). Checklist of Indian mosses. Bishen Singh Mahendra Pal Singh. Dehradun, India. 162.

Lal, J., Chaturvedi, S. K. and Jamir, Y. (2003). New distributional records of a rare and endemic moss *Fabronia assamica* Dix. (Fabroniaceae) from Nagaland. Abstract. *Nat. Sem. Advances in Bryological Researches*. P.G. College, Motihari, Bihar University, Muzaffarpur, Bihar. March. **17-20**: 2-4.

Nath, V. and Asthana, A. K. (2007). Current trends in bryology. Bishen Singh Mahendra Pal Singh, Dehradun, India. 1–387.

Sale, V. (2011). Studies of mosses of Kohima and Mokokchung districts, Nagaland. (Doctoral dissertation, Nagaland University, Lumami). Unpublished thesis. 345.

So, M. L. (1995). Mosses and liverworts of Hongkong. *Hongkong*. **1**: 162.

Subramanian, D. (2008). Mosses of Tamil Nadu. Bishen Singh Mahendra Pal Singh. 1 – 198.

Vohra, J. N. (1983). Leskeineae (Musci) of the Himalayas – Records of the Botanical Survey of India vol. XXIII. *Bot. Survey India.* Calcutta. 336.

Zhu, R. L. and So, M. L. (1996). Mosses and liverworts of Hongkong. *Hongkong*. **2**: 130.

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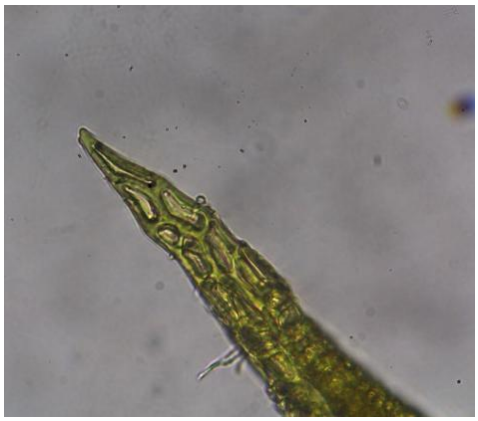
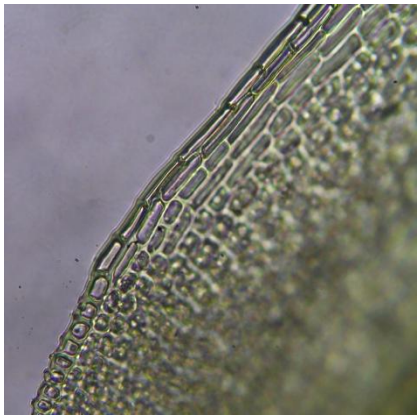
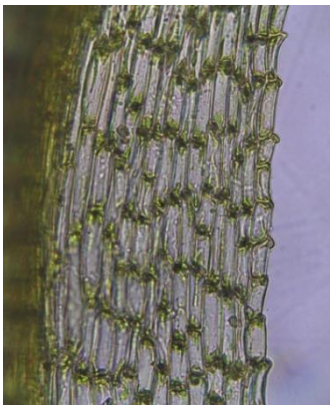



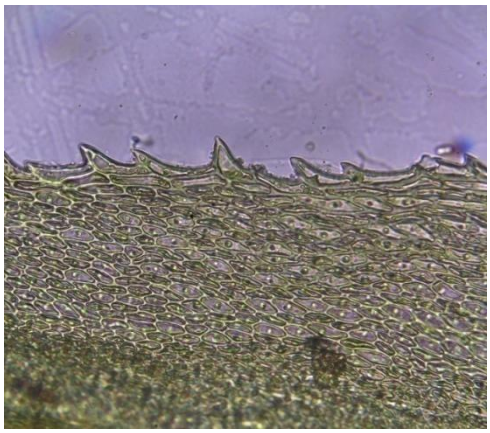
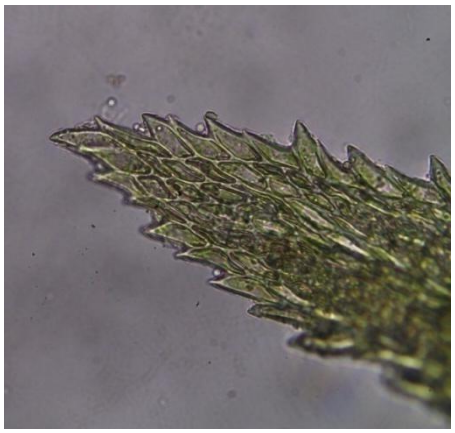
(A) Leaf apex (B) Leaf margin at the lower part

Figure 1: ***Weissia controversa*** Hedw.



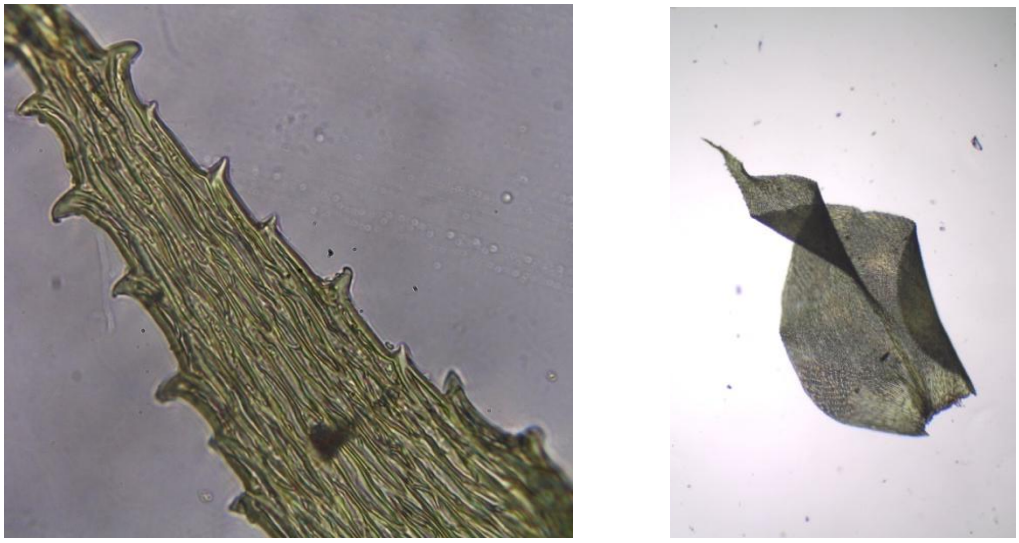
(A) Leaf lower cells (B) Leaf apex (C) Leaf upper cells

Figure 2: ***Bartramidula roylei*** (Hook.f.) Bruch & Schimp.

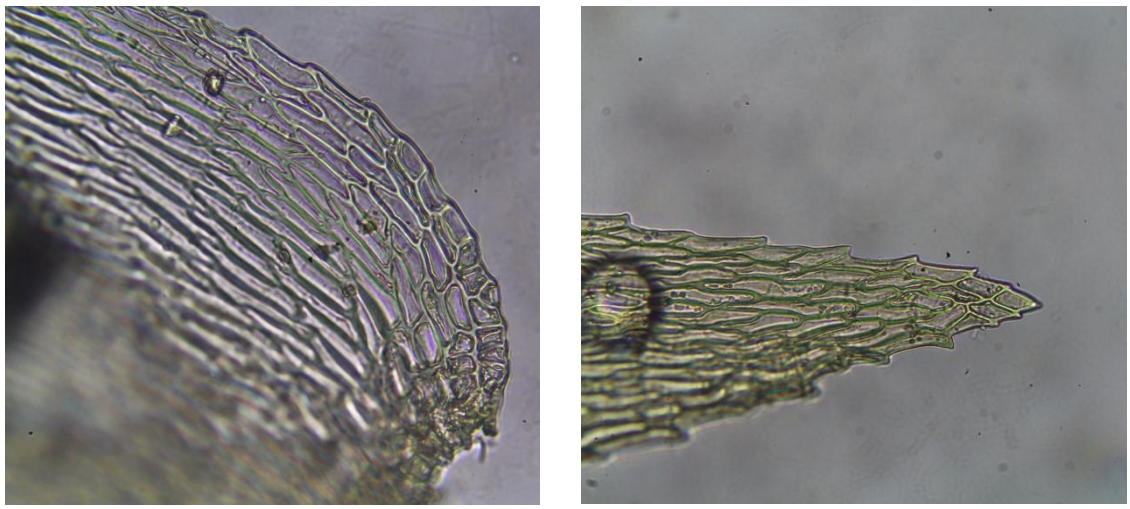
(A) Leaf margin (B) Leaf apex

Figure 3: ***Duthiella declinata*** (Mitt.) Zanten.



(A) Leaf apex (B) Leaf

Figure 4: ***Meteoriopsis ancistrodes*** (Ren. & Card.) Broth.



(A) Leaf base cells (B) Leaf apex

Figure 5: ***Taxiphyllum giraldii*** (C. Muell.) M. Fleisch.

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TENYIMIA KECÜKEKRIE KECHÜ MU KENYÜKECÜKO (FOOD PREPARATION AND TABOOS OF THE TENYIMIA)

Reviewed

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Puomho (Abstract): Themia ha mu rhei balieketuo la kecükekrie se morosuoyakezha la Tenyimia rei liecielierhi mhatho pie puo kelhou nu kemeyietho-u chü di puo ca puo va du cü vorkecü seyie puo. Kijü rhi kekreikecü ki ze ciethocieshü rei kekreikreikecü nyiya, Tenyimia ha telha cie pekrathoya mu se puo kecüca kemeyietho-u chü vor. Kecükekrie liro khutie mu zu pie teisonhie puo kecüca chükecü ngulie mu thie ketso rei khutie ha Tenyimia üyakezhako la kecüca kemeyietho-u chü ba zo. Hanie siekou themuo mu metsie ha puo kemeyie nyi phi di se u ca chü vor derei puotei pete nu nguliekezha vie mo. Vo di thekhruothenyi teiko zo mo liro themuonuoko cü peboya mo süla kecüca haha se mha kedi chü vor. Metsie liro u kijü nu nguliekezha vie mo süla tsu Assam nunu pfükecü dze u dzeweko nunu phrülieya. Keziedzü thechü/rüna huo nu ngulieya derei se di mechü kelhuo chükelie jü, keziedzü liro se vorlie di cha pesopie puo da chülieya. Hau pie gacha rei valie siro ciephrolie di pie u hiemvü rei chülieya. Ganyagara kekreikecü kekra pelhoupie puo ca chü siro ketsa nu gamenyie puorhi kekreikecü kekra sa cüya. U kijü vikecü ze di thechü kekreira ngulieya kemo gamenyie neiünei nyi mu sidi se u ca chü. Nhachünhara ha rei geipfü vor di cavitho chü vor. Tenyimia zhorüli ha Tsanau bu kekra hü bayakezha tuoi di kecükekrie kechü hako pete nu terhuomia ki theja kevi cha mu sidi kethezie kelhou puo lhou phre vor hu.

Cayie Diecako (Key Words): Tie, Zu, Kecükekrie, Kenyü

Sede Die (Introduction)

Telha repfü vor kitiekinu kengulie liro therietho-u kevaketelieya, puoca telhako kenyükecüu kekreilamonyü hako pete terhuomia theja üdi leyakezha la. Süsie süko pesepeme menuolie di se teicie va chü volieya. Telha thutuo liro phie pesolie perie thuya. Zoprie üdi keprü morei tekhra melhapie dolie di süko nunu telha phielieya, phie terhükecü cau liro telha süko bu so toulie tse thukecü teiki (lhako) thu pevikuolieya. Tsana nu ha u kecükekrie, bahurei teikhrie bu he kelhoukewako üse teikhrie lhapie iya mu süko cü la kenyüya kekreilamonyü süu theruo kesuo pie themia gei mo di u vie gei keshü zasi puo üdi leya mu kenyü rüürei liro terhuomia noupfhüu themia gei la vorketa prei üya. Khutie chakecü liro dzü kerüdapie balie di lhakoko khashülie di cha pesolie di cüya. Mia pete rei liecielierhi chü vorkecü kemhie di keriekimiakoe khunhie va se khutie cükecü chü vor; khise, khinhie mu theva. Ga huo cha kreilie di pie khutie chakelieu mvü cüya. Gacha liro kezapie; galuo, galho ikecü kekra chü volieya mu ganya kevazhü mu kemoko ha rei si krei di u thuo u kecükekrie zhorüli nu vi phi vor. Thakie puo, kevakezhü ganya, chüchie dzacie; kese khuvie, chüsi metsie; chuguchüte chüruchünya.Themuo ha khatho, vo thekhruothenyi teiki puo, kenyikeremia chümetsie chü di u thinuo, ramia pehekecü teiko nu moro kesiakejü teiki theprie üdi themuo biepie kezayakezha teiko nu zomo liro puotei penyi phi süla kelhe haha ngukelie teiki sü kecükekrie cü ketheguokelie chülieya derei thepriechü cü di ketheguolie ücü pu kenyüthor üya. Kenyükecü cau liro kesiakejü u gei vorketa kepreiu. Kenyikeremia huo liro chüwe, puoca themuo pegupie teicie gava rei chü volieya üsi. Sümhie di thekhruothenyi teiko nu kicükiri dukhri rei puotsü mu puomelou khapie mia tsüwa kenyü üya kekreilamonyü hanie liro theja ücü la. Theja sünie pie mia tsükewa zasi nie sie u kiri kruolie moketa preiya.

Tie (Rice)

Tenyimia dze thukecü, '*A hai ketuo, vo Himalaya-tsatie liecielierhi chü pevi seyakezhatsatie zorei tekhou kechü ha vor hatsa de chü pevi lotsokecü ngu chie mozo. Uko mhatho hau ġeinu uko mhasi we seketa mu ngu pevikecü rhi ngulie*' isi. ("I have never, even in the better-cultivated parts of the Himalayas, seen terrace cultivation carried to such perfection, and it gives a peculiarly civilized appearance to the country." Godwin-Austen, H.H, *The Nagas in the Nineteen Century*. lha.11) Tenyimia ha telha pie puo ca

kemeyietho-u chüya mu liecielierhi chükecü kenyakera, ganyagara kekrei rei pelhouya zo derei telha ciekecü pie kemeyietho-u chüya. Tenyimia kijü ha mehoshü liro puo kijü kro mu vi siro Rünuo Kemerie Kemehe (*Red clay soil*) üdi rünyo puo zie merie-meyhakezhau ngulieya. Rünyo hauha liro dzü rei tepfü pevi baliekezha puo mu rünyo hako nu telha ciekecü kevitho kekreilamonyü telhaboe dzü se seyakezha nha puo. U kijü nu teile teisei, '*sub-alpine climate*' üdi puotei vithor, teile teiu liro 16° Celsius-31° Celsius mu teisei teiu liro 4° Celsius-24° Celsius doki ngulieya. Puo teila kevi ki ze di kijü kekreira ngulieya kemo ketsa nha gamenyie kekreikreikecü thuo tshupfü di süko rei se u ca u va chü vor we.

Kijü nu telha puoyie kekreikecü 40,000 mese bakecü silieya mu hako liro '*Rice Gene Bank*' üdi telha tsia kengupie keba kezhatho-u, Los Banos, Philippines nu ba. MKS Dieda nu liro Tenyimia nhalie lha kekreicü 31 mu tekhoulha kekreicü 36, Chütienuo puoyie kekreicü 13 mu Kesi yie 2 idi thupie ba. Hau geinu mehoshü liro Tenyimia rei telha yie kekreikecü kekra se di keyie se vorzhükecü silie. Teicie puo nu puotei kekreikecü dia nyi mu süko liro Teiso, Bayie, Metsü mu Therü. Teiso teiu sü teisei teiute mu teisozha dzü mu teizeizha cha votaya. Puotei hau nu tekhouko hie sedetaya mu nhalie rei chü kemesakecü sedelietaya. Bayie teiu liro tsia kekreikecüko khashü sede, nhako tsü rüla partaya mu sidi u chiebieko la mhatho sedetaya. Süsie Metsü teiu partatuo, teirü sede lertaya mu tekhou thoko chü chüse partaya. Süsie Therü teiu mu hateiu nu thoreko tseiwa di u ciethoko ketheke teiu partaya sidi, deizhü, tekhu rhe ikhoya sidi pechamo di nhalieko re sede lataya. Hamhie di teicie nu puotei kekreikecüko geinu mhatho zhako keza se tuoya. Hamhie di teicie puo nu puo cietho kekreikecü 4/5 nyiya, sükosü; tekhoulie, nhalie, tshülie, kesilie mu shükolie. Keriekimiako ha pete rei zhorhe puo chü di Pfutsana nanyü ha medzi vorkecü chü. Pfutsana nanyü ha terhuomia thuo mha pete chüshü mu se bakecü peleya. Haha la terhuomia preithor vor kekreilamonyü puo neikemo chüwata morei nanyü huo chü kekrüwata liro terhuomia siezha pie u tsütayakezha peleyakezha la. Nanyüu bu puo kelhou pete kekha se tuokecü la mhathomhachü kehoupuo chü ürei terhuomia bu rie mu terhuomia nei chü mekecü ngulieya. Liecielierhi kechü nu rei mehoshü liro, puo ciethotei kekreikreikecüko nu, mhathomhachü kekreikecüko pete nu terhuomia thezie, theja kevi cha, terhuomia bu puo ciethocieshü pekrupeviepie puo tsü nukecü kecha idi puo mhatho pete sededekecü ngulieya

Telha yie kekreikecüko rhevi chü di, tierie/tiekra mu kemephuo/kemenya idi cü vor. Khutie gei *carbohydrate* üdi 28% baya mu u mhacako pekrekeshü teiki umo la kekuo se morokesuou hau geinu ngulieya. Protein liro 3% mu hau liro uzhüdako la viya mu süsha 68% liro dzü. Kecüca kehoupuorei se pekrakecü sü umo la viya mo siro u chienuokoe terhuomia ki kedeikepu cha, puoca mhacü petsalie di u lhacülhale kengu pekralie morokesuou idi u rhie u hie chü mhachü u mo kephra di shürhoshürhei vor we. Haha leshü liro, keshürho chatsa terhuomia ki theja chakecüu sie chatha kekrei ngulie mo derei puo kelhouzho peteu kerümou bakecü ngulie. Khutie chalie di cütuo liro u khou kakelie sie khutie sü puo kenie thekrepie u teikhie mvüwa, puoca cü di kesitheke bu u vata molieketuo la siro sümhiecü puo thekrepie kijü rei shüya, puoca terhuomia ya üdi. Kethezie pie terhuomia tsükecü zasi geinu hamhie di kecü metsei terhuomia theja la kethezie mhatho chü meya.

Zu (Liquor)

U pfutsanuokoe zu pie u krie kemeyietho puo chü vor. Ukoe dzü rei krie petsa phiya, seikra puo krieya mo siro mithu peri rei thunudzü rei kriekecü vovü leya mo. Mithunudzü krie kenyü icüu mo derei thekecü dojü rei mo mu thetuo ürei puodo rei siya mo üya. Tsana nu liro mithu ha puo kiriko donu kemeyietho puo mu mia puoe mithu peri pekralie liro terhuomia theja üdi kenyimia lanu partaya. Nacünanyü puo chü ürei puo thuko la rei theja cha ithaya süla puo kiri süsü bu kekruoketheu chülieketuo la u thu nuonuoko bu puo nudzü kriekezhüde krielie morokesuo la rei sa puo nudzü thekecü chüya molie vi. Zu chükecü rei telha, kemenya pie chüya mu kekreikecü kenie; Zutho mu Khe chülie di se u krie chü vor. Chütienuo mu kesi rei se khenuoko chülieya. Zutho liro, mereizu mu zudi idi puo ca kekrei di chüyakezhau geinu petho kekreipie baya. Teisonhie zu khrieyakezha la zu thukecü hako liro puotei puo pemvü morei nanyü puo chü di chü zoya mo derei morokesuou geinu chülieya. Zudi liro vo thekhruothenyi kemeyieko nu morei mia puo chümetsie chükecü teikiko nu zu chüyakezhako üse siya. Zu hako ha liro nanyü

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zukecü la thulieta liro zuko kenyü, chü kemesalie, phichümia bu metha riewa idi kekreimiako bu krie voya. Khe mu Zutho chükecü la khrei kekreiya, khrei liro zu chükecüu nu bie peseshüyakezhau mu puo kekuo hau la themia zu krie liro meze partaya. Khekhrei chükecü khekhreizhü üdi nha kro puo nyiya, huo puobo chü huo puoro chü mu huo nha kemene kro puo iya. Khekhrei chüketuo la thou zuopie balie di khekhreizhüko rei thusapie puozü chülie di dzü pie reilie di kenyo bolietuo. Zoprie khrashülie, phiekuo kezapie zoprieu nu shülie di khrei nepiekebako ciethepie tholei delielie di pie phiekuoko mho khapie zhüwaya. Zha huoyo sie süko pou parlie mu rüyie rümholieta liro pa kengupie teinia nunu phielietuo. Rüyiekecü hau liro puokhu puo geinu siparlieya mu süu bu zuko peseshüya. Lhako chalie di khutieko kapie lieherü kemhieko geinu pekulie, khekhreiko thusapie valie di kereikelie sie lapie merha nu shülie di nhanyü se shüpie bawatuo sidi zha puo sie merhau chüpie gali kemesa yopuo nunu puodzüko pezupie bawaya. Zha se (3) puo sie kheko rhalie vi parlieta liro rhapie gali huo nu shülie mu puo dzü zupie kebako pie tshe la pie bawaya sidi zha kenie puo ge ro krielie vi partaya. Zutho la khreiu liro lhamie petselie di lapie merha nu shülie di khriehenyü pie shüpie bawatuo. Zha 3-4 puo sie lhamieko tsü parta liro se vo chazou teinia nunu phielie di se zu valie vitaya. Lhako pie zu chüketuoko petsepie merha nu balie di pou za parlie liro ciekhe nunu thoulieya. Süsie pie vo thoutsherha nu shülie di dzü kerüdapie tshelie mu kerhü pevi selieya. Thouko kerhütshielie di pekulieta liro khrei pie valietaya sidi zha huoyo sie meluo parta liro dzü pie rhülie di pie liki morei zutseko nunu shüpie bawaya. Tei kele kemeku geinu khreiu zu va pesekecü puotei kekrei bataya, tei le liro zu sie vi üya, puoca krie zilie vitaya. Sümhie di zuko krielie vi parta liro shüpie liti morei sübako gei bawaya.

(Liti)

Lhou keriemiakoe Zutho krie ro themia va pevi mu kemetei üdi Zutho ha rhu phi vor. Ukoe teisozhau pete zu krie tuoya derei süpfü la üdi khatho huo morei vo thekhruothenyi tei huo nu mo liro miapuorei mezemelo tuoyacü chü vor mo. Zu krie liro kerie depie hiepou chülie di pieya siro kerhü, metsie, kevü hamhieko pie u hiemvü chülieya. Pheretuoli chü mia ki mere liro zu krie vi rei mo ürei shüpie u somia tsü meya, haha pie ketsükezakecü kevitho puo üdi leya. U hie puo krietuo liro terhuo kethezie rhiu nunu pie uteikhie mvüwa, puoca kesitheke bu u vata kelho süsie tehie mho huoyo tapie kijü shüwa perie nu krieya. Terhuomia theja süsü kriekecü mhodzü pie terhuomia kethezie zasi chükecü cau. Thie kecükekrie setuo liro cha pie puo sede chü di Kepenuopfü thezielieyakecü rhiu geinu mha hako medzi vor.

U chienuoko pete Tsana nunu lhou sierkecümia phre mu chüterhü ha pie thepfumia rüzhü kezhatho puo chü vor. Terhü whuotuo liro huoki zha 2-3 morei sükezhie rei tuotayakezha dze puya mu süteiko nu u ca kesekecü puorhi kreiya. Thou thulie di pie niekhrüda rielie, kenie thuopie thulie sidi pie niekhrüda sa rhe kesalie di perü kemetoupie niebo/niekhrü chülieya. Hau liro khrü mhataya mo süla thekhrükezie balieya süla rühouketuo teiko nu se u ca chülieya mu u merü rei vi üya. Hau üse ‘terhü tiedze’ ireiya.

Gacha (Dishes)

Sededie nu kepukeshü kemhie di ga liro kekreikecü kekra cüya, *('ga' icü die hauha 'gajo' icü zau nunu se par mu süu liro ga u cako pu ba)* hako huo u thuo pelhoulieya siro kekra ro nhaga. Thakie huo; jothoü, gathere, gara, gakra, zierüprü ikevo kekra nyi. *'...theva rei khise rei galho chü cü pekraya*' (Sorhie, Vikielie, 1993, lha. 33) Gajo hako liro umo va pevikecü mhaca kekra nyi mu sidi haha cü di shürhoshürhi di teisonhie u mhatho chü vorkecü ngulie. Ga hako cükecü liro luotaya mo, umelou kechü la vi siro uzie rei khotaya mo. Themuo liro *calorie* üdi umo bie peleshü di süu geinu kekuo khashüyakezhau ngulieya derei hauha krata liro umo la vi mo mu gajoko nu liro hau tsa phiya. Ga hako kechükenyü doneiü la rei vikecü chüya; nietso uzie kekra la vi, thebuothezu kesuo gathere vi, rüza huo pfüta liro gara vi idi kekreikecü nyi phi. Teiso teiki ha gamenyieko ngulie re partaya süla ga kekreikecü kekra pie gaki chü di pie gacha va cü la volieya. Gakrie, gakhro, kecienyü ikevo kekra nyi. Dzünuo, rümo kemhieko liro ba pecha philieya süla hako üse kemevo ca üya sidi kevaketekecü teiki kecaüca rei cülieya.

Peciekecü ca (Fermented Foods)

Tenyimia ha kecüca pecie cükecü kro puo nyi mu se pekrathoyakezha huo liro Dzacie, Kese, Tsütuocie. Kecüca pecie cükecü hau liro thiedzütho nu chü tuoketa vie puo mu mhaca kemeyietho puo liro kecüca hako ba pecha philieya. Kecüca peciekeshü gei *probiotic* üdi puokhu kro puo kecücau bie peze pevikuoshüya mu sidi cükelie ki uvadi nu u va kepeviko te pevikuolieya. Uzie kekreikecü kenie nyi, kekra puo mu kemerie puo iya. Kecüca peciekecüko cükeshü geinu uzie kekrau bu kechükhu kekrei u vakecüko ze keperhielie kevi chü pekrashüya. Shüdza ha Asia nu ngu pekratholieya mu sükemhie di hauha se kecüca kekreikecü kekra chüya. Tenyimia liro Dzacie chülie di se u gacha va morei pie tathu chü pekraya. Shüdza peciekelie hauha cükecü, u mhaca kre vi, uru metei, umelou kechü la vi, uzie kekra la rei vi idi mhaca kekra nu themo-u khruohiyakezha nyi. Japanmia rei '*natto*' üdi u Tenyimia dzacie ze kekhravü perekecü puo cüya sümhie di Indonesiamia rei '*tempeh*' üdi shüdza peciepie kecüca chükecü puo nyi. "*...an Angami may be often seen chewing chillies or raw ginger root for pleasure.*" (Hutton, H.J, 1969, lha. 94) Hutton leshü nu hamhie di thupie tuo mu u Tenyimia ha thie ketso rei chüsi mu kevü ha pie gacha vakecü kemeyietho kenie. Zu puo krie rei morei nhasi kekhro huo lecü rei chüsi kevü pie mvü cükecü u nei phiya. Chüsi mu kevü nu ha u va kepevi bathor, kemeyie puo liro, *antioxidants* üdi umo gei u la vi kemoko penyü, chü kemesashüya. Hako umo-u chü pekuokeshü geinu kechü doneiü rei hielieya. Thakie puo, terhuothie (*cancer*) khu rei ze keperhielie kevi daru nyi sümhie di mepfhüruo kemhiekecüko hielie rüükuoya.

Tieligali (Pottery)

Kecükekrie cha pesepeme cükecü pete rei rünyo li seya mu hauha u va kepevi rei kekra nyikecü ngulie. Tenyimia kelhou mehoshü liro u thuo se morokesuoko pete chü se vor derei rünyo li hau liro rüna pete chü vor mo. "*The clay from which they are made is only obtainable from certain villages...*" (Hutton, H.J, 1969, lha. 57) Kijü chü kekreikecü ze di se rünyoli chüliekevi rünyo kreikecü huo nyiya mu rüna huonu rübei ngulieyakezha chü di rüna sümhieko bu se lhidi chü vorkecü chü. Kecielikhi pete rei sei kerie kerhepie se vor. Mi chülie, ketsie se se ketoulie gali pie puomho dzalie morei sei depie vor misu chülie di mhachalieya. Nhaterha nu kecükekrie chü liro nhanyü kemesa kekreikecü; tepfhenyü, pfhünyü kemhieko pie mekhou chülie di pielieya. Zu kriekecü la lepou depie tehie chülieya moro süsü jüta liro tepfhenyü kekhrepie theü chülie di pielieya. Thekhruothenyi tei huo nu kewi kia pie hiekia chü di pieya.

Kenyükecüko (Taboos)

U chienuoko kecükekrie kekra cü krie kenyükecü nyi. Kenyü iliro nanyüu geinu pie puo kepeleu mvülie mu hako puoca nyi phre di medzi vor. Ketholeshü nu Kepenuopfü khunuo huo üse mesa mo üdi cü hienukeshüko kekratsa u krünuoko rei süko üse mesa mo üdi thenumia bu cüya mo. "*Khunuo donu puomou pro di puo ca suokecü pete nie-e cülie vi. Derei puo ca suokecüko morei puomou rükokecüko donu, nie hako cülie lho: ut-e puo ca suoya derei puomou rükomo, süla nie la mesa mo. Mu, Konuo puo ca suoya, derei puomou pro mo, süla nie la mesa mo. Zogazu puo ca suoya, derei puomou pro mocü la, nie la mesa mo. Siro thevo puomou pro mu pra ketsieya derei puo ca suo mo, süla nie la mesa mo. Nie süko chü cülie*

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lho, mu uko kesiamo bielie lho, sükoe nie la mesa mo… mu perako donu hako bie kenyütuo. Süko cü kenyü; süko kerütse zo: süko tsüü, chürhaü, ketsavünho,. Khunuo tekecü moupfü, mouvi kekreikecü pete…" (Levimiako 11) Ketholeshü dze kephrümia pukecü rei hako üse mesa mo icüu sie kedipuo la shicü thu toukecü ngulie mo derei *'dieze kechü hauha morosuokuokecüu penou di pu.'* (South Asia Bible Commentary) Pera meikhako, thakie rümou kemhieko rei cü kenyüya kekreilamonyü terhümia bu u geikewa prei üya. Thenumia bu cü kenyükecü hazie rei kekra nyi siro nhicumia bu cü kenyükecü rei huo tuoya. Tenyimia ha u nuonuo khriethoryakezha ki ze mha kevi pete pie u nuonuo ya chüya derei puo kelhouzho-u nu mehoshü liro kecükekrie kechü nu mha keza cü morokesuo zho-u se ler medzikecü geinu pekra. Mha pete pie nhicumia ya chüwata liro ketsakechiemiako ya jütatuo. Mhanuü phichümia cülie vi mu nhicumia cü kenyü iro phichümia rei süu cü liro u va pesuowa zotuo. Nhicumia thetetheriera (pera) cü kenyü. Hau cü kenyükecü kepreiu liro u yie tsaketa keprei tsiu sia zitaya üya. Thevüdzü mvüketako rei nhicumia cü kenyüya süla hamhieko ngulie ro pie ketsakechiemia ya chüwaya. Khunuo khru ha rei nhicumia cü kenyü üya sümhie di pera puomei puodza chükecüko rei cü kenyüya kekreilamonyü hako cü liro u nouyie suotaya üya. Zorhünuo (pera kecü yopuo) rei cü kenyüya kekreilamonyü tekhu mie pie puokru chüya ücü la. Sokrosokro, pera hau liro krüdzünie puomie mehe merie idi zivi phikecü ra puo derei cükecüu monyü zivi üdi pu rei kenyü kekreilamonyü u krü sia ziketa preiya.

Thenumia bu kenyükecü cau liro, thenumia ha kitiekinu lhacülhale mho pepupelou kechapfü süla keli thezu rei cü kenyü. Khunuo hanie liro u lhacülhale zomonyü lie nu u ciethocieshüko rei vawayakezha la üdi thenumia bu cü kenyüya. Puoe cü kenyükecüko cü liro kecüca kerüzie preiya süla cükecüu monyü tieligali, kecielikhiko rei bie kenyüya. Khunuo, pera cü kenyükecüko ha kenyükecü ca kekrei phre derei petekhre rei chü kekrei te cü layakezha zho u gei tuo phre lakecü ngulie mu süla hako pete üse mesa mo ükecüu nu leya. Chü kekhriekezei bu khunuo tekewa cadoko rei cü morei bie rei kenyüya, hako pete üse rhu ükecü letaya. Dzüra Zemvüü rei cü kenyüya kekreilamonyü pera hau khuo te cü layakezha la. Süsie Chümengaü rei cü kenyü. Chümengaü liro seiboko gei lhou tuoyakezha tepfi kemhie khunuo puo, puo ca krie za 75% nhanyü, ruosiruonyieko cüya derei za 25% liro khunuo kecü; guorünuo, tinyhü kemhieko tecü layakezha ngulie.

Thepfumia liro u phou kekuokeyho chaya sidi chüterhü, thecathebie mu nhachürühouko pie kemeyietho chü vor. Sekre di chü geilie morokesuo la theja chaya, puo rümia geilieketuo la nanyü chüya. Thuthe therietsa kepukeshü kemhiei di Zowhe pie puo khaya mu nha hauha liro mehiempriekecü puo süla theja cha di puo phou bu, '*kezowhe kezohutuowe*' iya puoca, u phou bu meguomega di kekuou chüliecie icüu. Nhachürühou chütuo liro u thuo phi, kemhonyü ba di chüya mu hako liro pete se u ca u va chüketuo la pekuoya. Thepfumia liro cü kenyükecü thenumia deya mo derei chü kekriekezei tekhu socienuoko geilie rei se vor phekijü nunu thenumia rüüreiya mo. Hako liro pete se pa casie nu chacütuo morei kitie nu misu zielie di cha krei cütaya.

Diethela (Conclusion)

Tenyimia kecükekrieko mehoshü liro pete rei u thuo ciekelie mu u kijü nu ngulieyakezhako se u ca u krie kevitho chü vor. Kecükekrie hako pete meho menuoshü liro u va kepevi nyithor phre mu mhasi süu sa se kerüduo di nnhienhienu u chienuoko kecükekrie kechü nu; kesekecü mu cüükriekecü peteko nu terhuomia thezie di lhou vi vor hu. Pfutsana nanyüu nu 'kenyü' dieu bu puo kelhou-u pete kekhase bayakezha kemhiei di zhorüli kevi kekra süko geinu tsü mu the parkecü ngulieya. Thakie, kecayhuo ro menga, u khutie hiezu pekawa kenyü isikecü mha kekra tuo. Mha hako pete rei puo kelhouzho nu lertaya, sidi kelhouzho-u chü pevishülieya. Hakemhie di Tenyimia kelhouzho ha vi ükecü cayie hamhieko geinu chiese parlie vi. Thie liro leshümhasi vorkelie ze u krü u pfutsanuo caükrieko ha meho kesa di mha kekra se tuo zo mu süko gei puo mhasi pfhü pesou lakeshü geinu ngu lakelie chülie bawe.

Kekhruohi Leshüdako (References)

Hutton, J. H. (2003). The Angami Nagas. Kohima: *Directorate of Arts and Culture, Govt. of Nagaland*. Print.

Keyho, K. (2015). Tenyimia Liecielierhie Kechü Dorhü. Dimapur: *Heritage Publication House*. Print.

Kuolie, D. (2018). Keriekimia Mhasimhale: Kenyü mu Menga. Kohima: *Ura Academy*. Print.

Mezhüvilie, Keduosievi & Shürhozelie (2001). MKS Dieda. Kohima: *Ura Academy*.

MLA (2009). MLA Handbook for Writers of Research Papers(Seventh Edition). New Delhi: *Affiliated East-West Press Pvt Ltd*

Elwin, V. (1969). Nagas In The Nineteenth Century. Bombay. Oxford University Press. Print.

Neichüriazo (2003). Tenyimia Kelhou Dze. *Kohima: Ura Academy*. Print.

Sekhose, K. (2002). Zhozho. Kohima: *Khrieü Sekhose*. Print.

Sorhie, V. (1993). Tenyimia Kelhou Bode. Kohima: *Ura Academy*. Print.

Zhale, K. (1995). Tenyimia Kelhou Dze. Kohima: *Ura Academy.* Print.

Web:

https://en.wikipedia.org/wiki/Fermentation

https://en.wikipedia.org/wiki/Unclean_animal

https://en.wikipedia.org/wiki/agriculture

https://en.wikipedia.org/wiki/Staple_food

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DEVELOPMENT AND CHARACTERIZATION OF GLUTEN FREE SORGHUM BASED FERMENTED BEVERAGE

Reviewed

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Abstract : Sorghum is a gluten free nutritious crop with various micro and macro nutrients. The sorghum base probiotic beverage developed is rich in various nutrients and probiotic which help to prevent various health issues. In this study the probiotic character, the nutritional and anti-nutritional as well as the sensory characters have been studied.

Keywords: Fermented sorghum, nutritional quality, organolaptic quality, probiotic, shelf life

Introduction

Sorghum is genus of poaceae family with 25 different species. Among these 25 species the commonly grown species and native to Africa is Sorghum bicolor. Sorghum plays an important role in agronomy as it can bear a wide range of environmental changes. Sorghum crops are tolerant of drought, so it can be easily cultivated in semi-arid tropical and in areas where it is difficult for other crops to resist the environment. It is widely cultivated as food for humans, animals feed and also the production of ethanol.

Sorghum is a nutritionally rich crop. It is rich source of vitamin B complex such as Thiamine, Riboflavin and Niacin. It is also rich in minerals such as Calcium, Iron, Magnesium, Sodium and Zinc. The bioactive compound present in sorghum has a unique profile and is mainly composed phenolic acid, flavonoids (3-deoxyanthocyanidins) and condensed tannins. Being gluten deficient, it is the best option for people suffering from celiac disease. Also, it contains minerals such as copper, which is necessary for the intake of iron by the blood cells and prevents the iron-deficient anemia common in women and children living in developing countries such as Asia and Africa. Sorghum is rich in caloric and good energy booster for those who do extensive exercise.

One of the drawback of sorghum is the presence of anti-nutritional compounds such as tannin and phytic acid. These anti-nutrition present in the sorghum hinder the protein and starch digestibility which make the sorghum an unutilized crop. To improve these properties various processing techniques such as soaking, germination, malting and fermentation can be used. These processing techniques break down several compounds that alter its shape, size, aroma and taste.

There are numerous of processing techniques to transform sorghum into food but fermentation is still one of the oldest and the most popular technique because of its beneficial function. Fermentation changes the flavor, texture and nutritive value of the sorghum. Generally, fermentation by lactic acid bacteria (LAB) is widely used in the food and beverage industry, while yeast fermentation is also important for making bread, cookies and other bakery products. The LAB fermentation improves the palatability and acceptability and enriches the nutrient by microbial synthesis of vitamins. It also reduces the anti-nutritional factor-like phytic acid and tannins, improving the protein and starch digestibility and increasing oil-binding capacity, emulsifying capacity, and emulsifying stability decreasing the water-binding capacity.

The environments in which LABs thrive are rich in proteins, sugars, vitamins, nucleotides and fats, which explain their predominance in sorghum microflora. These microfloras are healthy and safe and promote probiotic features. The probiotic mostly contains gram-positive bacteria that are catalase-negative rode with

round ends and found in pairs, short or long chains. They do not form spore and are non-flagellated and non-motile and are intolerant to salt. These benefits are particularly advice to children elderly and other high-risk population. The probiotic is effective on various gastrointestinal disorders. It may include prevention and alleviation symptoms of traveler's diarrhea and antibiotic-associated diarrhea, inflammatory bowel disease, lactose intolerance, and protection against intestinal infections, and irritable bowel syndrome. Some probiotics can reduce the prevalence of atopic eczema , vaginal infection, rheumatoid arthritis, liver cirrhosis, and enhance immune response in healthy elderly people. Various probiotic obtains from sorghum products are rich in several photochemical, reducing cholesterol and reducing the risk of cancer and diabetes. They generate vitamins, fatty acid, and other vital nutrients that improve the body's resistance against human pathogens.

A probiotic drink made up of sorghum can have a positive effect on health. This is because sorghum is rich in nutrition as well as it fermented sorghum is rich in probiotic. Moreover, most of the probiotic drink present in the market is made up of dairy products that cannot be consumed by those suffering from celiac disease. So the sorghum based probiotic beverages is beneficial in respect of health and nutrition.

The objectives of this study are:

1. To develop sorghum based fermented beverage.
2. To *In Vitro* Probiotic characterization of LAB isolates.
3. To analyze the nutritional and anti-nutritional properties of fermented beverage.
4. To analyze the sensory and physiochemical properties of fermented beverage.
5. To analyze the shelf life of optimized beverage

Methodology

Procurement of Ingredient

The main two ingredient of the beverage was Sorghum and Whey water. The Sorghum grain was procured from the local market of Prayagraj, U.P. To procure the whey water cow milk was boiled , few drops of vinegar was added while starring which made the water to separate from milk and was freshly used while preparing the beverage.

Product Formulation and Standardization

Preparation of malted sorghum flour

The sorghum grain is socked in distilled water for 24 hours at room temperature. After 24 hours water is drained off and then the grain is tied in muslin cloth for 48 hours at ambient temperature (22-25 ^{0}C) for germination. The germinated sample is dried using hot air oven at 70 ^{0}C for 4 hours. The processed sorghum grain in ground in an electric blender equipped with stainless steel blades to make flour. The flour is kept in an air tight container.

Product formulation

The sorghum flour is mixed with water to make it into thick and smooth slurry. The slurry is cooked at 80-85 ^{0}C for 15 minutes. The slurry is allowed to cool at room temperature. After the slurry is cooled, it is inoculated with culture of lactobacillus and then allowed to ferment at 37 ^{0}C for 12 hours. The fermented slurry is kept in a air tight container in refrigerator.

Treatment and Replication of Fermented Beverage

The fermented slurry is added with whey water to make it into a thin beverage. Roasted Cumin powder and black salt is added before serving it.

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Table 1: Ratio of ingredients in different treatments of gluten free sorghum based fermented beverage.

TREATMENTS	INGREDIENTS	PROPORTION
To	Non- Fermented slurry: Whey water	**1:1**
T1	Fermented slurry : Whey water	1:1
T2	Fermented slurry : Whey water	1:2
T3	Fermented slurry : Whey water	1:3

In Vitro* Probiotic Characterization *of Lactic Acid Bacteria Isolates.

Acid Resistance and Bile Tolerance

Acid resistance was tested using MRS broth adjusted with HCl to a final pH of 2.0 and3.0, and bile tolerance will be assessed with MRS broth containing 0.3% (w/v) oxgall (Oxoid, Basingstoke, UK).

Cell Surface Hydrophobicity

Isolate cell hydrophobicity was determined following the method of Ekmekci et al. (2009), which is based on the affinity of cells (cultured overnight in MRS broth) for toluene in a two phase system**.**

Auto-Aggregation Assay

The auto-aggregation ability of each isolate was measured according to the method described by Shin *et al.* (2012).

Antibiotic Susceptibility

The minimum inhibitory concentrations (MICs) of Ampicillin, Streptomycin, Gentamicin and Ciprofloxacin with respect to the selected lactobacilli will be determined using a broth microdilution test (Garcia *et al.,* 2016)

Antagonistic Activity Against Pathogens

Antagonistic activity against pathogens was determined following the method of Garcia *et al.,* (2016).

Chemical Analysis of Product Formulated

Analysis of Nutritional Compounds;

Methods described by AOAC (2007) were used for determination of nutritional composition of fermented sorghum. This included estimation of moisture, ash, fat, protein and carbohydrate was calculated by difference method.

Analysis of Anti-Nutrition Factors

The phytate is extracted with the trichloroacetic acid and precipitated as ferric salt.The iron content of the precipitate is determined calorimetrically and the phytate phosphorous content was calculated from the value assuming a constant, 4 Fe: 6P molecular ratio in the precipitate.

Sensory Evaluation

Samples of fermented beverages was given to the trained panel members for evaluating the sensory attributes such as color and appearance, consistency, flavor and test, and overall acceptability of the product through nine points Hedonic scale method (9 and 1 points showing like extremely and dislike extremely).

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Physiochemical Analysis

The pH of the beverages was determine using pH meter (Titumum U9N model) and titrable acidity will be determined by titrating 10 mL of the homogenized sample against 0.25 mol/L NaOH (1N) using 1 mL of phenolphthalein indicator (0.5% in 50% alcohol).

Microbiological Analysis

The viable counts of *Lactobacillus* (CFU/g) was determine by the standard plate count method on MRS agar plates and incubating for 48 h at 37 °C. The yeast and mold count of fermented beverage will be determine using potato dextrose agar medium after incubating for 48 h at 37 °C. The coliform bacteria on the MacConkey agar will be incubated at 37^{o}C for 48-72 hours.

Shelf Life

The optimized beverage was withdrawn at weekly interval to examine the impact of storage period on the physicochemical properties and microbial load.

Results and discussion

Product formulation and standardization

The probiotic sorghum beverage was prepared by fermenting the sorghum and mixing it with whey water in different proportions i.e. T_0 (1:1), T_1 (1:1), T_2 (1:2), T_3 (1:3). The sorghum slurry of T_1, T_2, and T_3, was fermented for 24h with Lactic acid bacteria where as the slurry used in T_0 was non –fermented.

Chemical analysis

Nutrient Composition of Fermented Sorghum

Table 2: Average nutrient composition of fermented sorghum

NUTRIENTS/100g	RAW	FERMENTD	T-VALUE
Moisture (g)	11.9	10.60	6.32*
Ash(g)	1.6	1.87	0.90
Protein (g)	10.4	10.1	0.71
Fat (g)	1.9	3.32	7.36*
Carbohydrates (g)	72.6	68.7	21.19*
Crude Fiber (g)	1.6	6	16.74*
Calcium (mg)	25	27.3	6.97*
Iron (mg	4.1	10.6	26.53*
Energy (kcl)	349	316	22.48*

***Significant ($p \leq 0.05$)**

Table 2 depicted the high nutritive value of fermented sorghum over raw sorghum flour. It is a rich source of macro and micro nutrition and moisture contain.

Fermented sorghum has shown to improve the nutritional qualities, palatability and consumer appeal. Fermentation increases the bioavailability of vitamins and minerals because the absorbance of foliate, riboflavin and amino acid are increased during fermentation. LAB has the ability to change iron into more absorbable ferric form so the iron content is increased in the fermented sorghum. It has found that protein in raw sorghum has low digestibility, whereas fermentation enhance the quality of protein by removing excess carbohydrate, concentrating amino acid and making amino acid more digestible. Fermentation also decrease the starch quantity and the dietary sugars that are poorly absorbed in the small intestine and promote healthy digestion and contributing neutral balance of intestinal microflora.

Table 3:Phenolic Content

NUTRIENTS/100g	RAW	FERMENTD	T-VALUE
TPC (mg/100g)	202.5	195.8	36.45*

***Significant ($P \leq 0.05$)**

Table 3 shows that there was decrease in the phenolic content of the fermented sorghum as compare to the raw.

Similarly, *Braun et al., (2005)* studied the variation of sorghum phenolic compound during the preparation of bear and observed p*henolic* compounds affect the rate of fermentation,

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quality and stability of sorghum. Fermentation decreases in the levels of proanthocyanidins about 52 and 34% during the lactic fermentation stages.

Anti-nutritional factors of fermented sorghum

Table 4: Average anti-nutritional factors of fermented sorghum

NUTRIENTS /100g	RAW	FERMENTED	T-VALUE
Tannin (mg)	33.15	28.37	15.37*
Phytate (mg)	556.52	247.92	1279.12*

***Significant (P ≤ 0.05)**

Inspite of high nutritional value, sorghum are underutilized crops due to the presence of anti-nutritional compounds. These compounds reduce the digestibility and availability of essential nutrients and reduce the nutritional quality of sorghum. Fermentation is the traditional techniques has been use to reduce the content of antinutrients such as tannin and phytate and which helps to increase its nutritional quantity and protein digestibility.

***In Vitro* Probiotic Characterization of Lab Isolates**

Acid Resistance And Bile Tolerance of *Lactobacillus* Strain

Table5 :Final counts (Log CFU/ml) of LAB strains

pH	*L. casei*	*L. acidophillus*	*L. plantarum*
Control (0 hrs)	8.3 ± 0.09	7.9 ± 0.10	8.1± 0.14
pH 2.0 (4 hrs)	5.6 ± 0.12	4.5 ±0.12	7.8±0.19
pH 3.0 (4 hrs)	7.5± 0.45	7.5 ± 0.95	8.0 ± 0.15
Bile			
Control (0 hrs)	8.5± 0.19	8.1± 0.14	7.9 ± 0.15
0.3% (4 hrs)	4.5± 0.14	5.7 ± 0.18	7.2± 0.10

The pH of the gastric juice is considered among the vital factors affecting the survival of probiotic bacteria during their passage through the stomach to the intestine.). Indeed, previous studies have shown that the viability of LAB between pH 2 and 4 is an important indicator of potential probiotic performance (Garcia et al., 2016). In the present study, strains of *L. casei, L. acidophilus* and *L. plantarum* were examined for their pH and bile tolerance capacity. It was found from the experiment that all of the three strains have shown an appreciable viability at pH 2.0 and 3.0.

Tolerance of bile during transit through the gastrointestinal (GI) tract is essential for probiotic LAB to survive, grow, and exert their beneficial effects (Jena et al., 2013).The strains were subjected to 0.3% bile solution and it was found that all the strains have shown viability on exposing to bile solution but strains of *L. plantarum* have shown the highest growth.

Cell Surface Hydrophobicity and Auto-Aggregation

Table 6 : Assessment of cell-surface hydrophobicity (%) and auto-aggregation (%) activities of LAB strains measured after 4 h of incubation.

Strains	Cell Surface Hydrophobicity(%)	Autoaggregation (%)
L. plantarum	41.65± 1.5	36.4 ±1.4
L. acidophilus	37.05±0 .75	28.5 ± 1.2
L. casei	25.89 ± 0.85	18.5 ± 1.25

The LAB isolates in the present study differed widely with respect to hydrophobicity, with *L. plantarum* exhibiting the highest value (41.65 ± 1.5%), followed by *L. acidophillus* (37.05 ± 0.75 %)(Table 6). These results suggest that the complexity of the cell surface mosaic resulting from hydrophobic and hydrophilic appendages and other macromolecular components might lead to differences in hydrophobicity. Furthermore, all the isolates exhibited some degree of auto-aggregation, with the highest level being demonstrated by *L. plantarum* (36.4 ±1.4%), followed by *L. acidophillus* (28.5 ± 1.2%) (Table 6).

Antagonistic Activity Against Pathogens

Table 7 : Antagonistic activity of culture supernatants of LAB strains against pathogenic bacteria.

Strains	***E. coli***	***S. aureus***	***Salmonella***	***Pseudomonas***	***B. cereus***
L. plantarum	++	+++	++	+	-
L. acidophilus	+	+++	++	+	-
L. casei	+++	+++	+++	++	+

The antagonistic activity of the LAB isolates against selected pathogenic bacteria is presented in Table4.3.3.All the strains have shown antibacterial activity against *E.coli, S. aureus, Salmonella spp*. and *Pseudomonas spp.* The extent of antagonistic activity was found to be in the sequence of *S. aureus> E.coli>Salmonella spp.>Pseudomonas>B. cereus.*

Antibiotic Susceptibility

Table 8: Antibiotic susceptibility of LAB strains

Strains	**% of isolates**	**Diameter of zone of inhibition (mm)**											
		Ampicillin (mg/ml)			**Streptomycin (mg/ml)**			**Gentamicin (mg/ml)**			**Ciprofloxacin (mg/ml)**		
		2.5	5.0	10	2.5	5.0	10	2.5	5.0	10	2.5	5	10
L. plantarum		5	10	12	4	8	15	7	18	24	6	9	15
L. acidophilus		NI	NI	5	NI	5	10	8	12	16	NI	5	10
L. casei		NI	NI	5	NI	10	15	NI	NI	5	NI	10	15

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Bacteria intended to be used as probiotics should not carry transmissible antibiotic-resistance genes as that may lead to the development of new antibiotic-resistant pathogens (Saarela *et al*., 2000). In present Study the strains were tested against Ampicillin, Streptomycin, Gentamicin and Ciprofloxacin at concentrations of 2.5, 5.0 and 10 mg/ml . The strains were found to be susceptible against all the antibiotics used in the study. Strain of *L. plantarum* was found to be susceptible against the lower concentration of antibiotics but strains of *L. acidophilus* and *L. casei* were found to be resistant against the lower concentration of these antibiotics.

Table 9: Organoleptic Characteristics of The Prepared Product

PARAMETERS	T_0	T_1	T_2	T_3	F	CD
	MEAN±SE	MEAN±SE	MEAN±SE	MEAN±SE		
Colour And Appearance	7.2±0	7.5±1.7	7.5±1.7	7.9±1.7	1.60 (1.84)	0.4
Consistency	7.5±0.11	7.6±0.08	7.8±0	7.2±0.08	1.59* (1.19)	0.6
Flavour	6.8±0.11	7.2±0.11	7.9±0.14	8.2±0.09	1.56* (1.24)	0.6
Overall Acceptability	7.1±0	7.5±0.08	7.7±1.1	8.1±1.1	2* (1.23)	0.7

***Significant**

The sensory test of the product concluded that the treatment T_3 was most like by the panel member which consists of the fermented sorghum and whey water in the ratio of 1:3.

Physiochemical Analysis

Table. Summarizes the physiochemical parameters (pH and titrable acidity) of beverages(treatment T_3), revealed that there is significant difference ($p<0.05$) for each of the parameters at the end of storage period of 30 days.

Table 10 : Physiochemical profile and *Lactobacillus* count in the beverage during storage at 4 ^{0}C for 30 days

Days	pH	Acidity
0	4.7^a	1.3^b
7	4.4^b	1.8^a
14	4.2^c	2.1^c
21	4.1^c	2.2^c

Each values represent mean±SD and p<0.05 significant.

Shelf Life

Table 11: Shelf life Study of treatment T3

WEEK	Coliform Count (cfu/ml)	Yeast and Mold count (cfu/ml)	Lactobacillus count (log CFU/ml)
I	0	0	8.3
II	0	0	8.05
III	0	0	7.86
IV	0	0	7.12

Shelf life of the product is the length of time for which a commodity may be stored without becoming unfit for use, consumption, or sale. Growth of undesirable and pathogenic microorganisms shows the unsuitability of the product for consumption. The products were tested for presence of yeast and mold for estimating the shelf life of the sample. It was found that for sample T3 the presence of yeast and mold observed in fifth week of storage. Hence the sample was found safe for consumptions up to 30 days of storage.

Conclusion

This study concludes that the beverage made by fermentation of sorghum contains probiotic microorganism which are beneficial to improve the gut microflora. Sorghum can be fermented and successfully be utilized to make products to enhance the sensory and nutritive qualities. The chemical analysis for the beverage indicates their moisture, ash, fat, carbohydrate, protein, fiber, calcium and iron content and concluded that the beverage is a reach source of energy and carbohydrate. The phenolic content and the anti-nutrition factors were also reducing due to fermentation which enhances the nutritive value by improving the protein and starch digestibility.

For the improvement of sensory attributes, whey water was incorporated with fermented sorghum. Whey water is lactose free liquid was used in different ratio to produce different treatments. The treatment T_3 that contain the highest ratio of whey water was highly acceptable by the panel member when compared to control $T_{0.}$

This study has proved that including the sorghum base probiotic beverage in daily life can help to improve immune system by improving the gut microflora. It is also rich in nutrition's and help to improve the health condition.

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Refrences

Azeke, M. A., Egielewa, S. J., Eigbogbo, M. U. and Ihimire, I. G. (2011). Effect of germination on the phytase activity, phytate and total phosphorus contents of rice (*Oryza sativa*), maize (*Zea mays*), millet (*Panicum miliaceum*), sorghum (*Sorghum bicolor*) and wheat (*Triticum aestivum*). *J Food Sci Technol*. **48(6)**: 724-729.

ButchiLakshmi, K. and Vimala, V. (1996). Hypoglycemic effect of selected sorghum recipes. *Nutrition Research*. **16(10)**: 1651-1658.

de Morais Cardoso, L., Pinheiro, S. S., Martino, H. S., Pinheiro-Sant'Ana, H. M. (2017). Sorghum (*Sorghum bicolor L.*): Nutrients, bioactive compounds, and potential impact on human health. *Crit Rev Food Sci Nutr***. 57(2)**: 372-390.

Gautam, N. and Sharma, N. (2014). Quality attributes of a novel cereal based probiotic prepared by using food grade lactic acid bacteria. *Indian Journal of Traditional Knowledge*. **13**: 525–530.

Jood, S., Khetarpaul, N. and Goyal, R. (2012). Effect of Germination and Probiotic Fermentation on pH, Titratable Acidity, Dietary Fibre, β-Glucan and Vitamin Content of Sorghum Based Food Mixtures. *Journal of Nutrition & Food Sciences.* **2(9)**: 2-164.

Joseph, M. A. and Lloyd W. R. (2004), Sorghum phytochemicals and their potential impact on human health. *Phytochemitry* **65(9)**: 1199-1221.

Kumar, H., Salminen, S., Verhagen, H., Rowland, I., Heimbach, J., Bañares, S., Young, T., Nomoto, K. and Lalonde, M. (2015). Novel probiotics and prebiotics: road to the market. *Current Opinion of Biotechnology*. **32**: 99–103.

Kunchala, R., Banerjee, R., Datta, S. and Mazumdar, P. D, (2013). Characterization of potential probiotic bacteria isolated from sorghum and pearl millet of the semi-arid tropics. *African Journal of Biotechnology*. **15(16)**: 613-621.

Naik, Y. K., Khare, A., Choudhary, P. L., Goel, B. K. and Shrivastava, A. (2009). Studies on physicochemical and sensory characteristics of whey based watermelon beverage. *Asian Journal of Research in Chemistry*. **2**: 57-59.

Parvez, S., Malik, K. A., Ah Kang, S. and Kim, H. Y. (2006). Probiotics and their fermented food products are beneficial for health. *Journal of Applied Microbiology.***100(6)**: 1171-1185.

Salmerón, I., Thomas, K. and Pandiella, S. S. (2015). Effect of potentially probiotic lactic acid bacteria on the physicochemical composition and acceptance of fermented cereal beverages. *Journal of Functional Foo*ds, **15**:106-115.

Thakkar, P., Vaghela, B., Patel, A., Modi, H. A. and Prajapati, J. B. (2018). Formulation and shelf life study of a whey-based functional beverage containing orange juice and probiotic organisms. *International Food Research Journal*. **25**:1686–1692.

Xiong, Y., Zhang, P. and Warner, R. D. (2019). Sorghum Grain: From Genotype, Nutrition, and Phenolic Profile to Its Health Benefits and Food Applications: Comprehensive Reviews in Food Science and Food Safety. **18(6)**: 2025-2046.

UNDERSTANDING NUCLEAR ENERGY- PROCESSES AND ITS IMPACT ON HUMAN AND ENVIRONMENT

Reviewed

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Abstract: Nuclear energy is the energy of the atomic nucleus with two nuclear processes – fission and fusion. Nuclear fission is the splitting of an atom's heavy nucleus into smaller fragments; nuclear fusion is the combining of atomic nuclei to form heavier nuclei. A byproduct is release of energy. Nuclear energy is a nonrenewable energy. Overcoming challenges of operational safety and nuclear waste management will be crucial in enabling nuclear energy as a major source of energy. This paper basically highlights fission and fusion energy, radioactive wastes, its impact on human and environment and also summarizes advantages and disadvantages of nuclear energy.

Keywords: Nuclear energy, fission, fusion, radioactive elements.

Introduction

Nuclear energy is the energy of the atomic nucleus. Nuclear energy is a nonrenewable energy. Nuclear energy originates from the splitting of uranium atoms- a process called fission. Uranium occurs in three types in nature: uranium-238 – 99.3% of natural uranium; uranium-235 – about 0.7%; and uranium -234 about 0.005%. Uranium-235 & uranium-238 are two naturally radioactive isotopes of uranium. U-235 is the only naturally occurring fissionable material (processing uranium called enrichment to increase the concentration of U-235 from 0.7% to about 3% which is used as fuel for the fission reaction). About 1% of uranium is actually utilized to produce steam for generating electricity. In short nuclear fission is the splitting of an atom's heavy nucleus into smaller fragments whereas nuclear fusion is the combining of atomic nuclei to form heavier nuclei. A byproduct is release of energy.

Fission Energy

The nucleus is the centre of the atom which is normally made up of the same number of protons as it has neutrons. However, some very large nuclei in certain isotopes have an imbalance. They can often be found with too many neutrons, and this imbalance will result in the nucleus becoming unstable. Nuclear fission is a very efficient source of energy because of low amounts of waste products. Combustion of fossil fuels produces waste products as ash and toxic fumes.

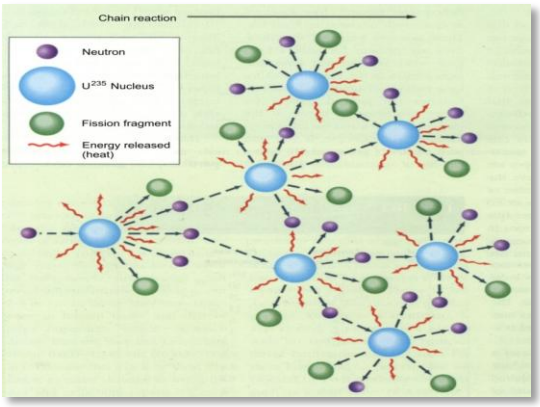

Fig. 1: Fission Reaction

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Fusion Energy

In fusion heat energy in released. Nuclear fusion in the source of energy is our sun and stars. In fusion reactor two isotopes of hydrogen-deuterium and tritium – are injected into the reactor chamber. Products of DT fusion include helium, producing 20% of the energy released, and neutrons, producing 80% of the energy released. It requires 100 million degree centigrade of temperature for DT fusion. Secondly, the density of the fuel elements must be sufficiently high. Thirdly, the plasma formed (electrically neutral, consisting of positively charged nuclei, ions and negatively charged electrons) must be confined for a sufficient time to ensure that the energy released by the fusion reactions. If fusion power plants are developed the supply of potential energy is nearly inexhaustible.

Deuterium can be extracted economically from ocean water.

Tritium can be produced in a reaction with lithium in a fusion reactor.

Lithium can be extracted economically from abundant mineral supplies.

Half Life of some radioactive elements

Half-life of a radioisotope is defined as the time required for one-half of a given amount of the isotope to decay to another.

Types of Nuclear radiations

There are three kinds of nuclear radiations:

Alpha – two protons + two neutrons, high mass, do not travel far only 5-8cm; in human tissues 0.005-0.008cm; very toxic to human if inhaled or ingested. Less harmful when keep in container.

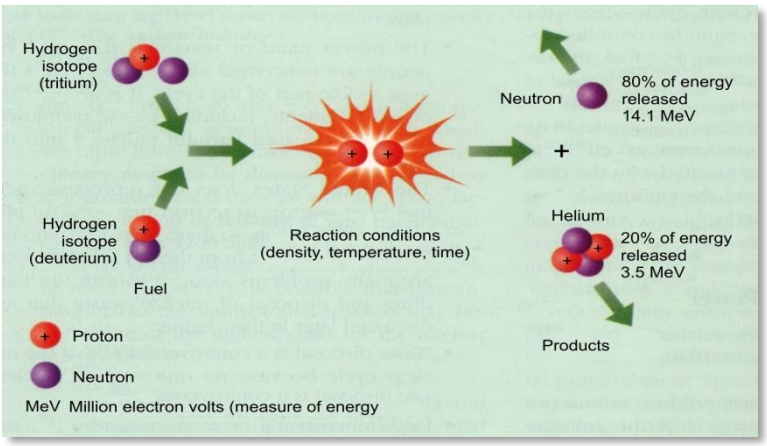

Fig: 2 Fusion Reaction

Sl. No	Radioactive elements	Duration
1	Half-life of U-235	700 million years
2	Half-life of U-238	4.5 billion years
3	Half-life of Thorium-234	24.1 days
4	Half-life of C-14	5570 years
5	Half-life of Radon-222	3.8 days
6	Half-life of Polonium-218	3 minutes
7	Half-life of Lead-214	27 min
8	Half-life of other radioactive isotope	fraction of a seconds
9	Half-life of Radium-226	1622 years

Table: I: Half-life of some radioactive elements

Beta – Beta particles are small, fast-moving particles with a negative electrical charge that are emitted from an atom's nucleus during radioactive decay. Some beta particles are capable of penetrating the skin and causing damage such as skin burns. However, as with alpha-emitters, beta-emitters are most hazardous when they are inhaled or swallowed.

Gamma – an electromagnetic radiation, γ-ray similar to x-ray but more energetic and penetrating even thick metallic shield. γ-emitters are toxic and dangerous inside or outside the body**.**

Radioactive waste

Radioactive wastes are the byproduct produced at nuclear reactors. They are grouped into two general categories:

Low-level waste - It includes residuals or solutions from chemical processing, solid a liquid plant waste, sludge, and acids; and slightly contaminated equipment; tool, plastic, glass, wood and other materials. Low level waste has been buried and monitored in near surface burial areas. The leaks of liquid waste may pollute groundwater.

High-level waste -High-level radioactive waste is very dangerous. It lasts for tens of thousands of years before decaying to safe levels, so this is a major hurdle to overcome before nuclear power can expand. Half life of some radioactive elements is shown at Table-I.

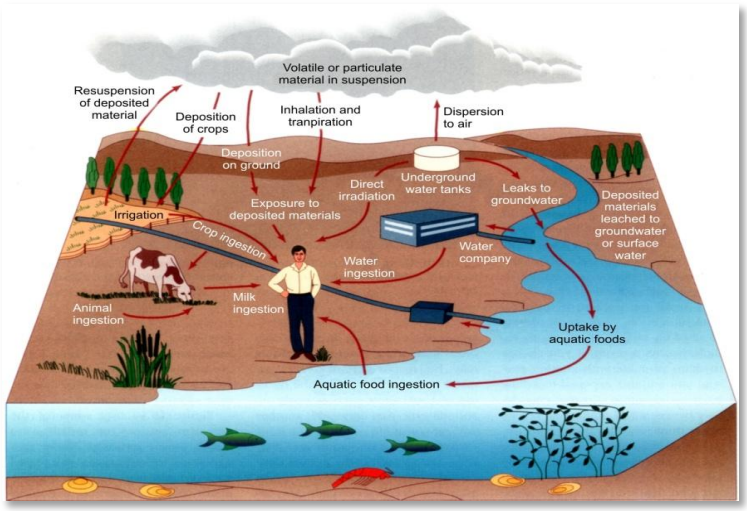

Fig. 3: How radioactive substance reach humans

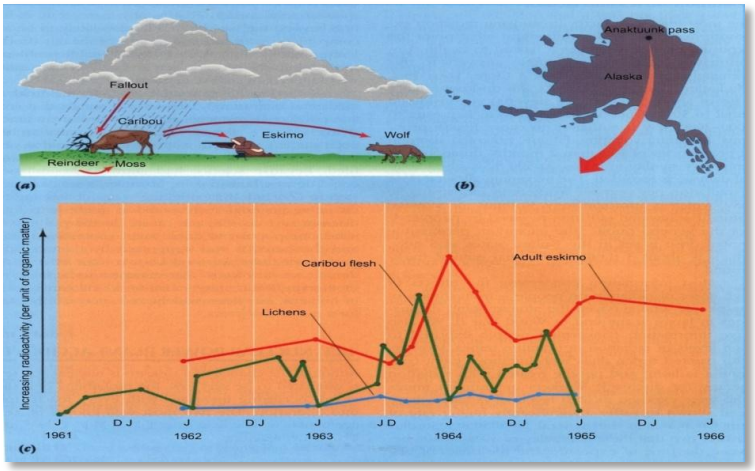

Fig: 4: Radioisotopes affecting environment

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Materials and methods

Understanding two nuclear processes, ie fission and fusion and their by-products are paramount in the present case. Challenges of nuclear energy as major source of energy and its impact on humans and environment both positive and negative are being presented here. The secondary method of data collection has been employed and the sources of information and data are basically collected from books, personal sources, journal, newspaper, seminars, workshops, website, etc.

Result

Nuclear energy as a major source of energy will depend on whether it can overcome the challenges of operational safety and nuclear waste management. Some of the major challenges are:

- Uranium mines and mills produce radioactive waste materials that can pollute the environment. Radioactive mine tailings have been used for foundation of building materials and have contaminated dwelling.
- Uranium- 235 enrichment and fabrication of fuel produce waste materials that must be carefully handled and disposed of.
- Problem of site selection and construction of Nuclear Power Plant is extensive and expensive.
- The Nuclear Power Plant or reactor releases harmful radiation into the environment.
- Waste disposal is a controversial part of the nuclear cycle because no one wants a nuclear waste disposal facility-nearby.
- Decommissioning or modernization of a Nuclear Power Plant they all have a limited life time of between 20 and 30 years is a controversial part of the uranium cycle.
- Transporting and disposing of nuclear materials are potential environmental hazards.
- Terrorist activity and the possibility of irresponsible persons add a risk in producing other than energy production.
- Fusion in comparison is more attractive from environmental point of view:
    - First, land-use and transportation impacts are small.
    - Second, fusion reactors produce no fission products and little radioactive waste and one less likely to be involved in an accident.
- Radioisotopes affect the environment in two ways -
    - emitting radiation that affects other materials and
    - Entering the normal pathways of mineral cycling and ecological food chains.
- Nuclear explosion cause damage to environment both ways -at the time of explosion, intense radiation of many kinds and energies is sent out, killing organisms directly.
- Explosion generates large amount of radioactive isotopes. Nuclear bomb produce as huge cloud that sends radioisotopes directly into the stratosphere which may be widely dispersed by winds.
- Atomic fallout-this is the deposit of the radioactive materials around the world.
- Radiation cause mutations, changes in the genetic messages within cell.
- A serious fault or mal-operation could bring about considerable damage to the plant and cause dangerously high levels of radiation or radioactive contamination.

Some environmental hazards may also be occurred due to (i) radiation from the core (ii) radiation from the coolant.

Conclusion

Although nuclear power cannot substitute fossil fuel entirely and become the sole sustainable energy resource, it can play a significant role in decarbonising the production of electricity. Some of the advantages of using nuclear power to produce electricity are –large fuel supply, low environmental impact (without accident), emits 1/6 as much CO_2 as coal, moderate land disruption and water pollution (without accidents) and moderate land use. The disadvantages are- High cost (even with large subsidies), low net energy yield, high environmental impact (with major accidents), Catastrophic accidents can happen (Chernobyl), no acceptable solution for long-term storage of radioactive wastes and decommissioning worn-

out plants and spreads knowledge and technology for building nuclear weapons.

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References

Armaroli, N. and Balzani, V. (2006). The future of energy supply: challenges and opportunities, Angew. *Chem. Int. Ed*. **45(2)**.

Brennen and Christopher, E. (2005). An Introduction to nuclear power generation, dankat publishing company.

Chu, S. and Majumdar, A. (2012). Opportunities and challenges for a sustainable energy future. *Nature*. **488**: 294.

Eisenberg, R. and Nocera, D. G. (2005). Preface: Overview of the forum on solar and renewable energy. *Inorg. chem*. **44**: 6799.

Ferguson, C. D. (2007). Nuclear energy balancing benefits and risks. *Council on foreign relations,* CSR No. 28.

Ghosh, A. R. (2011). *Toxicology: Some fundamental aspects*. *In 'Environmental concerns'*. edited by Debabrata Das Gupta, Publ. Agrobios, Jodhpur, India, ISBN No. (10) 81-7754- 428-4. 155-184.

Giusti, L. (2009). A review of waste management practices and their impact on human health. *Waste management*. **29**: 2227.

Murray and Raymond, L. (2001). *Nuclear energy*, 5th edition. Boston: Butterworth-Heinemann.

Sims, R., Roger, H. H. and Gregory, K. (2003). carbon emission and mitigation cost comparisons between fossil fuel, nuclear and renewable energy resources for electricity generation. *Energy policy*. **31**: 1315.

Smith, A. (1996). Global Warming Damage and the Benefits of Mitigation. Fuel and Energy Abstracts. **37(3)**: 221.

Toth, F. L. and Rogner, H. H. (2006). Oil and nuclear power: past, present and future. *Energy Econ*. **28**: 1.

Watson, R, Boudreau, M. C. and Chen, A. J. (2010). Information systems and environmentally sustainable development: Energy informatics and new directions for the community. *Management Information Systems Quarterly*. **34(1)**: 23-38.

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U TSIEPFUMIA PFHEKO KHÒ KEKREIKESHÜ (CLASSIFICATION OF ANGAMI FOLKSONGS)

Reviewed

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Mhathu mhó (Abstract): Angamimia ha thepfhetheü u nei seyakezha seyie puo. Ütsali u neiyakezha ki ze di u pfhe u ü krathorkecü zomonyü thepfhetheü rei vithor. Nnhiennhie nunu u krü u pfutsanuoko thepfhetheü kechü ha pie kelhouzho kemeyie mu kezivitho puo chü vorta zo. Puotei kekreikreikecü nu mu thechü kekreikreikecü nu chüyakezha pfhe puorhi kekreicü kekra chü tuoya. Miali chüyakezha pfhe, miatse chüyakezha pfhe mu miakra chüyakezha pfhe idi thepfhe kekreikreicü kra se. Thepfhetheü huo liro thekhruothenyi teiki kepechükepekro di chüya. Thepfhe süko huo ba chüsechü di chüya mu huo liro rüsierülou chü di chüya. Thenyi teiki chüyakezha pfheko zo kemo kechükelie teiko nu chüyakezha mhathomhachü pfhe rei kekreikreicü kra se. U krünuoko mhachü kesie pete nu thepfhe puokru puo pie mhatho puo reirei idi mhatho kehoupuo chü shierei thepfhe chü di chüya. Ü rei kekreikreicü baya, süko huo liro miali thuo chüya mu huo miatse chüya. Thepfhe kekreiko ki kreikhrokecü kro puo mechü rüsie mu nacünanyü kechü teiko nu chüyakezha rei nyi. Nhicumia thepfhe kereko chülie sü kemo teiki chü bayakezha pfhe rei kra phi.

Cali diecako (Key words): Lizha, nouza, litsie, chüthòmia, keyo, litá, cakiemia.

Sededie (Introduction)

U tsiepfumiako kelhou teiki kethukeru diemvü kejü la thedzethemieko pete tieyie nunu keyiese vor u tsolie. Sükemhie di u pfhe u üko rei phou puo sie puopuo idi kerünyü nunu dojüpfülie di keyiese vor u tsokelie zo. U pfhe u üko kethukeru nu tuo kemo la puozho puorei medzi tou di chü vorkecü ngulie mo. Zhorhe tuo kemo la kelhou tei kekreikecü nu thepfhe kechümia u thuo u kruu nunu chüchü idi thepfheko rei rüdi miemie vorta mecie. Siro puotei huo nu thepfhe huo pejüwa di thepfhe kekra chü vor u tso motalie vi. U krü u tsiepfumia pfhe chü tuoyakezha kicha kekreikreikecüko pfhe mehoshü ro kekrei zazakecü ngulieya. Kicha pfhe pulie kenjüü rüna kenie pfhe rei kemhie toukecü ngulieya mo. U tsiepfhumia pfhe hako thepfhe kechümia puo thuo zorei ndunhie chükeshüu mu ndu morei thie chükeshüu kekrei latakecü nyi. Sirei thepfhe rükhreko mu ligeko mehoshü ro puorá mu puokoureiko pete puomvüdze kemhie zokecü ngulieya. U tsiepfumia pfhe hako puotei kekreikreikecü nu chüyakezha, thechü kekreikreikecü nu chüyakezha, themia ketsa kekra chüyakezha, thepfhe rhi mu puozho kekreikecü hako geinu khò kekreikecü chülie vi.

Theba nu pfhe

Theba nu pfhe liro thepfhe lige nyi toukecü kro puo geizoko pie tsalica chü di keliya. Thepfhe hako themia ketsakekra pfhe kekreikreicü baya. Thepfhe hako üse ‘tsali’ idi pu rei lieya. Tsali kekreikreikecüko liro:

(i) *Lida*: Thepfhe chü dojü sedekecü teiki thepfhe kerüü kro puo chü di dojü sedeya mu süko üse ‘lida’ ireiya. Lida rei kekreikreicü kekra baya mu süko puotei kehoukipuorei chülieya. Lidako liro thepfhe kechümia la puo rübei di chüya mu süla chü ketsieya mo. Themia tsa zorei lidako kelilieya.

(ii) *Litsie*: Thepfhe kechümia la kenie chü di thepfhe chü ketsieyakezha pfheko üse ‘litsie’ iya mu hako liro themia kra di chüya. Litsie kechü nu tsalica kie kerie lau pie ‘cakiemia’ mu kekreiko pie ‘sienomia’ idi puya.

(iii) *Lizha*: Yho mu Whe kenyi pfheko üse ‘Lizha’ iya. Thepfhe Merielhou/Oh heleinuo, We-o, Oh-oh hakemhieko lizha phre. Thepfhe hako liro therieki rüli se mu shühie pecha se di sedeya. Thepfhe chü ba kenuotsa rükri votaya. Kracü teiko nu thepfhe hako se kemeyie seya.

(iv) *Kése pfhe*: Tsali kechümia la se chülie di keli ketsieyakezha pfheu üse ‘kése pfhe’ iya. Thepfhe hau theba nu pfhe kere mu kezivitho

puo. Themia kra di chü morosuoya. Thekra kecü teiko nu chü pekraya.
(v) *Kédia pfhe*: Tsali hau ro thepfhe kechümia la dia chülie di keli ketsieyakezhau mu süla themia kra morosuoya. Thepfhe hau rei theba nu pfhe keretho mu kezivitho puo. Thepfhe chü mezhieketamia mo liro chülie reya. Thekra kecü teiko nu chüya. Thepfhe kere Kédia pfhe kemhieko nu pfhekru (*part*) thenie ketso se di thepfhe chülieya. Pfhekru kekreikreikecüko liro- 1. Puorei/Nuosenuo, 2. Puonuo, 3. Nuorei/Thepfularei, 4. Laü/Thenularei, 5. Laürei/Kege, 6. Puokrü mu, 7. Krüdè.
(vi) *Libounuo*: Tsali kehoupuorei kie pecha mo mu miatsa/miatse thuo keliyakezhako üse siya. Süko huo kie rükri seya mu süko üse 'litá' idi puya.

Mhathomhachü pfhe

U krünuoko kelhou teiki mhachü kesie pete nu thepfhe chü di mhachüya. Mhatho puo la puopfhe kreikecü puo babakecü kra seya. Mhatho pfhe kemeyietho kro puo liro:
(i) *Wo…wo/Yiehie*: Thepfhe hau liro lie phiekecü mu tekhou hiekecü ki chüyakezha pfhe. Thepfhe hau üse 'therüliephie pfhe' morei 'teiseikhouhie pfhe' ireiya. Thepfhe hanu thenumiapfü puo bu 'wuo' lie mu kekreiko pete 'wuokrü' chüya.
(ii) *Dithodima pfhe*: Nhalie nu telhabo udziezhü chie parkezhü ki kejü kecü se di nhako kerhie mu telhako meza idi thepfhe chü tuoyakezhau üse 'dithodima pfhe' iya. Thepfhe hau üse 'wehawehie' idi puya. Thepfumia pfhenie üse 'wehie' mu 'weha' iya mu thenumia pfheu üse 'hiehanuo' iya.
(iii) *Dizhü pfhe/Liezie pfhe/Zoga kiva pfhe*: Thepfhe hau liro mhatho kekreikecü se nu chülieya. Nhalie nu telhabo uphico chie keba ki puo donu chü kemesa di thepfhe hau chüya. Thenumia 'le-ho' kie mu thepfumia 'oh-ho' kie idi ketsieya. Nhalie cieketuo la lie ziekecü ki rei thepfhe hau chüya. Mu thepfhe hau ki kechü ki zoga pie puotsü gei vakecü teiko nu rei chülieya.
(iv) *Khouse pfhe*: Thepfhe hau thenumia tekhou se di chü tuoyakezhau. Khouse pfhe nu rei pfhekru 'weha', 'wehie' mu 'hiehanuo' hako baya. Pfhekru kekreicüko 'he-ha' kie tuo di keyolieya. Mhatho-u u kekuo se sè zoya mokecü ki ze di thepfhe chü peto se zoya mo derei rülé di kepfherei kezivi selieya.
(v) *Khourei pfhe*: Tekhou hiekewa sie tekhou reiya mu tekhou reikecü ki chüyakezha pfheu üse khourei pfhe iya.
(vi) *Kepfükepie pfhe*: U chienuoko teiki mha pete u thuo pfü mu pieya. Mha kepfükepie ki chüyakezha pfhe krei toukecü baya. Gapie pfhe, sei kepfü pfhe mu sei kepie pfhe hakemhieko kekrei phre.
(vii) *Nuo kepfükecü pfhe*: Thenumia u nuonuo pfülie di u nuo kevuo pezewaketuo la thepfhe chüyakezhau üse nuo kepfükecü pfhe iya. Thepfhe hau 'o-iyo-we-ho' chü di chüya. Rüünuomia rei u siezemia pfülie di nuo kepfükecü pfhe chü baya. Thepfhe hau chü di u nuonuo ketsi pezewaya.
(viii) *Ciethu pfhe*: U chienuoko teiki ciekhe nunu kecü thu phreya. Keciethulie kevimia keciethu ro mia kenie ciekhe khere puo nunu kecieru di ciethu pfhe chüya. Thepfhe hau 'hi-yo, ho-wa' kie ketsie di puorükhreu mhatho meleu ze di chüya mu keyo rei lieya.
(ix) *Tshaze pfhe*: Lhoukeriemiako u thuo zotsha cielie di lapfü vor themvü geinu zepie kelo chülieya. Thenumia zotsha ze chakhrie chü bayakezha pfheu üse tshaze pfhe iya.

Ü

Ü liro tsaliko ki krei di thepfhe kechümia thuo lige kegepie u kru nu vo di keliya. Sükemhie di u medo kevimia u noule chiepie üca chü di kiepie kelilieya.. Ü rei kekreikreicü kekra ba.
(i) *Thupfhe ü*: U chienuoko teiki ki pete khre nu mithu periya mu mithu pfheyakezhamia u thu whuo ketsa nu lelie ro mithuko rüchükecü kemhie morei u thuo u rüli medopie ü chü tuoyakezha pfheu üse thupfhe ü iya. Hau miali pfhe puo. Thupfhemia thupfhe ü chüshü ro mithuko rei süu rünyü zeipfü di nha liecü tuolieya üsi.
(ii) *Tsanu ü*: Ketsa nu tsu mhayie liekecü teiko nu, kichüpeli kechü teiko nu mu chathela nu ketuo teiko nu tsanu ü chü tuoya. Tsanu ü chü kereilieya. Tiedie chü di pulie kereko rei ü nunu pulieyacü la khriesarüümia ü chü di u noule phrapie huoniehuo pesilieya mu ü nunu keprüli morei huo kengakecü rei chüya.
(iii) *Chazougei ü*: Chathela nu ketuo ki thechü kerükrieko geinu ü chü tuoyakezha pfheu üse

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chazougei ü iya. Kichüpeli chü di ketsukevo chü ketuo teiko nu ü chü ketsie tuoya mu thechü kerükrieko geinu chü pekraya.
(iv) *Theba nu ü*: Thekhruothenyi teiko nu kitiekinu kepekro di ü chü bayakezhau üse theba nu ü iya.
(v) *Weyu*: Thepfhe hau liro phichümia kepekrolie di morei miali zo shierei kinunu chü bayakezha pfhe puo. Phichümia ü hau chü mesümedepfü balieya üsi.
(vi) *Weü-oh*: Ü hau thepfumia rei chüya zo derei thenumia thuo chü pekrayakezha pfhe puo. Lietsulievo chako nu thenumia mia se dia kepfherei di chüya mu chü ketsie rei lieya. Ü hau keyu kechüko nu rei selieya.
(vii) *Thekrü*: Mia puo kesiakejü chüketa teiko nu u kekhriethomia u nou suo di u kero dieko pupie ü chü bayakezha pfheu üse thekrü iya. Thekrü ha puo lige puo nyi tou di nousuodie medopie khelie di chüya. U medo kevimia u nousuodieko pupie thekrü chüshü ro siazhiemia pete bu süsü rünyü di u nou mezhie philieya üsi.

Kehu

Kehu liro thepfhe kekreiko ki kreikhrokecü pfhe puo. Tsalica morei üca puorei sa mo di kehuya. Kehukecü ha pfhekru pengou baya mu kro kenie chü di ketsieya. Thepfumia kepekro di mele kesie pete nu kehuya. Rüli se mu puo üba (pitch) rei rünuo se di sedeya mu sidi rülili di rükrimiemie mu puo üba rei rükriemiemie vo di thelanu kete keno se vowa di khawaya. Kehu rei kekreikecü kekra baya.
(i) *Hutho*: Hutho liro phichümia mu khriesarüü chüsechüketamia kehu puo. Thekhruothenyi teiki kepekro pele keba teiko nu hutho kehuya. Kehukecü therieki rüli se mu tuo rüli siro whi pezha di sedeya. Thelatsa kehu rükri mu tuo rei rükri partaya mu whi pecü lertaya. Nanyü kechü teiki mu chüterhü gei se kevor teiki rei hutho kehu chüya.
(ii) *Seishü pfhe*: Hau thepfumia rübei kehuyakezha pfhe puo. Kehu hau khrietho rüna morei khrietho thinuo kidakinyi kechü teiko nu chüyakezha pfhe. Siro seishü pfhe hau kerütso di kepechükepekrokecü teiko nu pehümiako chü pekraya üsi.
(iii) *Tsiakrünuo/Kezonuo*: Hau hutho mhie derei ‘oh’ imo di thenumia bu ‘a’ lie di kehuya. Thekhruothenyi teiko nu khriesarüü kepekro di tsiakrünuo pfhe chüya mu sürübei zokemo peli lienu rei kehu hau chülieya.
(iv) *Pherekethu pfhe*: Thiedzü chüterhü kenyi tei gei rüna/thinuo puoe puo khrietho rüna/thinuo ze di kidakinyi chüta liro thinuo kekrei nunu khriesamia kepekrolie di thinuo süu phe lakecü chüya üsi mu süteiko nu kehu pfhe puo chüyakezhau üse ‘Pherekethu pfhe’ iya. Khriesamia kepekrolie di dahouko gei siro kidoko nu rühoukecü chü di pherekethu pfhe chü di mia peza chü tsiu u rüna pfheüla baya üsi.
(v) *Yhuohu*: Kehu hau liro nanyü kechü teiki chüyakezha puo. Chüthòmia lievükecü teiko nu siro chüthòmia ki hiekecü teiko nu chüyakezha kehu puo.
(vi) *Nouza pfhe*: Kehu pfhe hau puotei kekrei ki rei chüya zo derei thekra kecü teiki kehu hau pie thepfhe sedeu chüya. Kehu pfhe hau üse ‘zucha pfhe’ idi pu reiya. Nouza pfhe hau nouza üyakezha khunuo sokru tuoi di pruolieyakezhayo pfhe rünyü di chülie ücü *U Tsiepfumia Rüve* (Shürhozelie,U Tsiepfumia Rüve, 1982) leshüdau nu thupie tuo di ngulie. Kehu hau chümetsie kechümia kitiekinu rei chüyakezha puo. Mechühe nu kedeikepu theja chapie zudi mho keshü kehu puo. Zu liketa mhodzü thepfumia, phichümiako thuo zucha pfhe chüwa di süze mhazako sedeya. Hau tsevu 1 morei 1 ½ (1.30 minutes) kezie lieya mo.
(vii) *Leishü pfhe*: Hau rei kehu pfhe puo zo. Lei shükecü teiki chüyakezha pfheu. Leishü pfhe nu pfhekru se (3) rübei baya, süko liro ‘hoyie’, ‘hoa’ mu ‘ho’ (Meguo-o, *Introductory of the Folk Songs of Angami Naga,* [circa 2017] p. 11).
(viii) *Terhü kehu*: Kehu hau mechü rüwhuo chü di rüyachü nunu u rümia ze keperhiekecü teiki rei tsiu terhü/chüdi geilie di la khedi nu la kevor teiki chalanu terhü kehu chüya.
(ix) *Huyie*: Phichümia rei khriesamia rei chüyakezha theba nu kehu puo. Kehu kekreiko kemhie kehu ba di ‘whe’ mu ‘oh’ kepieko u pfheu shüthe moto di ba se (3) ketso shühie/shünyhüse vo di kehu kouri nu methou lalieya. Kehu hau Chedemia donu phichümia mu khriesarüümia kerei di kehuya. Kracü teiki rei hau se kemeyieya.
(x) *Nhicumia kehu*: Nhicumia lau kehu üse ‘Ho eah’ iya. Hau kibanuomia rei salieya.

Bahurei mechü rüsieko nu, kharu keshü nu nhicumia vo thetsa nu tsolie kelhoko bu ruodi kepenuora tha di le kero teshü di mia ze kepekrolieya. Nhicumia kehu liro phichümia kehu mhie di puo panuo tsa, pfhe kenie rübei mu la dia chü di kehuya.

Kehu kekreiko pfhe ki krei zakecü kro puo rei baya. Süko liro kehu mu chieli kesa di tsalica sa se keliya. Sükosü: 1. Sozie kechü pfhe, 2. Khuo chükecü pfhe mu, 3. Phita/Rülou pfhe (Ibid. p. 11).

Tati pfhe

Mia puo, mia kenie morei sükezie rei thepfhe chü di tati pepie reikecü chüya mu thepfhe süko üse 'tati pfhe' iya. Tati pfheko liro tati pekeshü rükhreu ze thepfhe chüpie kereiba voya. Tati pfhe rei kekreicü kekra baya.

Kibanuomia pfhe

U krü ze ketsukevo chülie sü kemoko zorei thepfhe chü baya mu thepfhe süko üse kibanuomia pfhe iya. Kibanuoko 'Hie rei nie demia, nie rei hie demia', 'A pfo vorlie, a pfu-o vorlie', 'Tei rü mo di kijü bu rütuo me?' hakemhie kro puo kie di keli baya.

Hako zokemo thepfhe kepetse kekrei kekra rei ba. Nyhüze pfhe, Kicha pfhe, Kise pfhe, Khuo kete pfhe, hamhiekecü kro puo rei baya.

Thekha die (Conclusion)

U krü u tsiepfumia u shiephruokeshü u pfhe u üko ha u kinyi puoma keretho kro puo zo. Thepfhetheü hako pejüwa mo di keyiese vor u tsokelie kemevi kekra bakecü ngulie. U pfhe u üko nunu u tsiepfumia kelhouzho keviko sikelie rübei zomonyü thedzethemie mu thedzetheseko rei silieya. Thepfhetheüko nunu u krü u tsiepfumia teiki krothokrochü dzeko mu mhathomhachü zhoko rei si salieya. U tsiepfumia tsalicako nu u die kesou kezivithoko rei tuo di ngulieyakecü la thepfhetheü pekrukelie geinu diesouko rei pejüwa monyü pie u vie chüse tuolie vi. Thie puotei rüdirüli kevor ze di u tsiepfumia pfheko pie ketheyie phi votazhükecü ngulieya. U pfhe u ü si mo mu rükra mo vota tse u kelhouzho kevi kekra rei pejüwalie vi. Siro u krü u pfutsanuo kelhouzho keviko pejüwa tse u kelhouzasiu rei pejüwalie vi zo. U pfhe u üko rhu mu rüguo lalie di keyiepie siekelhoumia tsü lashüketuo sü thie teiu nu kelhouko mese. U krü u pfutsanuoko keyiese vor u tsokeshü kinyi hako puoma re ücü sikelie geinu u seyie kekhrie nouleu rei chü penyipekralie viwe.

Kekhruohi Leshüdako (References)

Chücha, N. (1989). Tenyimia Kelhou Dze. Kohima: *Ura Academy*. Print.

Kuolie, D. (2006). Diemvü Rhitho Bodeko. Kohima: *Ura Academy*. Print.

Meguo-o, M. (2017). Introductory of the Folk Songs: Angami Naga. Kohima: Self Publication. Print.

Meguo-o, M. (2008). Uramia Liweko. Kohima: *Ura Academy*. Print.

Peseyie, V. K. Angami Traditional Music: A Critical Musical Analysis. *Silver Jubilee Souvenir* (1989-2014). New Delhi: Angami Krotho Delhi. 37-44.

Sekhose, K. (2002). Zhozho. Kohima: *N. V. Press*. Print.

Shürhozelie (1981). Phousanyi. Kohima: *Ura Academy*. Print.

Shürhozelie (1982). U Tsiepfumia Rüve. *Ura Academy*. Print.

Sorhie, V. (1983). Tenyimia Kelhou Bode. Kohima*: Ura Academy*. Print.

Zhale, K. (1995). Tenyimia Kelhou Dze. Kohima: *Ura Academy*. Print.

Media reference

Nhalie Kecie. Dir. Medongulie Rutsa. Perf. Kekhawakhrie Peli No. 8. Kohima, 2010. DVD.

Tekhoulie Kechü. Dir. Medongulie Rutsa. Perf. Kekhawakhrie Peli No. 8. Kohima, 2010. DVD.

Personal Interview

Chadi, Khriesanyü. Personal interview. 18 Apr. 2021.

Kuotsu, C. Personal interview. 11 Apr. 2021.

Mechülho, Meguo-o. Personal interview. 29 July, 2020.

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IN SILICO STUDIES OF SMALL ISOTHIOCYANATE MOLECULES AS POTENTIAL ANTICANCER AGENTS

Reviewed

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Abstract: Isothiocyanates (ITCs) are small molecules that are important due to their potential as anti-carcinogens. Through this piece of work, an effort was made to assess the anti-cancer activity of some small ITCs through *in silico* studies. Molecular docking was incorporated to understand the mode of ligand-protein interaction. ADME/Toxicity and drug-likeliness parameters studies have also been employed on the ITCs to assess their efficiency in anticancer activity. Results showed that all the isothiocyanate molecules understudy revealed drug-likeliness properties as an orally active drug. Molecular docking studies showed favourable binding affinities with the targeted cancer proteins. Tetradodecyl Isothiocyanate (PRO 10) showed the most promising and potential amongst all the molecules understudy.

Keywords: Oral cancer, Skin cancer, Isothiocyanates, Drug-likeliness, Molecular Docking

Introduction

Oral cancer is the sixth most common malignancy worldwide that can develop in any tissue of the oral cavity with low survival rates and high morbidity. Likewise, skin cancer melanoma is becoming more common and resulting in increased mortality (Huang *et al* 2014; Yeh *et al.* 2016). Despite intensive research efforts and novel therapies, the mortality remains high. Several epidemiological studies have reported that dietary intake of cruciferous vegetables, known to contain sulfur-based chemo-preventive isothiocyanates (ITCs), may lower the risk of various malignancies, including oral cancer. These isothiocyanates (ITCs) molecules are highly reactive organo sulphur synthons, with the general structure R–N=C=S. Isothiocyanates present in cruciferous vegetables are responsible for the plant sharp taste and active in its defence system (Newman *et al.,* 2012). They are derived from glucosinolates which upon loss of cellular integrity activate the enzyme myrosinase leading to generation of several unstable intermediates which rearrange into degradation products (Bianchini and Vainio, 2004). These degradation products are transformed into isothiocyanate, oxozolidine2-thiones, nitriles, etc. depending upon different factors like pH, presence of myrosinase interacting protein, and availability of ferrous ion (Kala *et al.*, 2018). Isothiocyanates are reported to be abundant in cruciferous vegetables such as broccoli, watercress, Brussels sprouts, cabbage, Japanese radish and cauliflower, and they significantly contribute to the cancer chemopreventive activity of these vegetables (Higdon *et al.,* 2007). Some isothiocyanates derived from cruciferous vegetables, such as sulforaphane (SFN), phenethyl isothiocyanate (PEITC), and benzyl isothiocyanate (BITC), are highly effective in preventing or reducing the risk of cancer induced by carcinogens in animal models. They also inhibit the growth of various types of cancer cells (Trachootham *et al.,* 2008; Lee *et al.,* 2008). A number of studies have supported the role of ITCs, especially sulforaphane (SFN), iberin (IBN), allyl-ITC (AITC), benzyl-ITC (BITC) and phenethyl-ITC (PEITC), in cancer prevention and chemotherapy (Mitsiogianni *et al.,* 2019).

Computer aided drug designing had become an important common component of the drug discovery toolbox, and its relative low-cost implications and perceived simplicity of use has stimulated an ever increasing popularity within academic communities (Berry *et al.,* 2015). Drug-likeliness prediction of a candidate compound and lead optimization tools such as molecular docking can be used to predict in where and in which relative orientation a ligand binds to a protein (i.e. binding mode or pose) (Leach, 1994). This information may in turn be used to design more potent and selective analogs through

virtual screening of the candidate compounds (Doss and Kumar, 2014).

In the present study, considering the potentiality of isothiocyantes as anticancer agents and *in silico* tools that are low cost and faster in screening candidate compounds, a library of small isothiocyanate molecules were screened for the drug likeliness and for their probable activity against skin cancer and oral cancer.

Materials and methods

Isothiocyanate library/ Ligand preparation

The isothiocyanates molecules understudy are shown in table 1. The 2D structure of isothiocyanates were generated with Chemoffice 2010. The energy of these compounds were further optimized using MM2 force field method and saved as sybyl mol2 (3D) file format using ChemBioDraw Ultra 12.0. (Pathak *et al.,* 2016).

Protein preparation

The three-dimensional (3D) crystal structure of the target proteins (Table 2) was retrieved from the Protein Data bank (http://www.rcsb.org) and it was imported in the Molegro Virtual Docker [MVD] (Molegro APS: MVD 5.0) software. For docking purposes, all the water molecules were removed since they were not considered during scoring. Considering the chains are identical and independent of one another, only chain A from the enzyme was imported in the MVD to perform the molecular docking simulation (Vinoda *et al.,* 2016).

Table 2: Cancer type and the target protein used for the study

Type of Cancer undersudy	Selected target enzyme/protein (pdb id)
Oral cancer	3ppo, 1gii
Skin cancer	2vcj, 3sao

Table 1: Isothiocyanates understudy

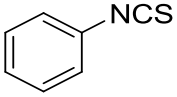
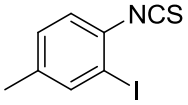
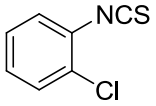
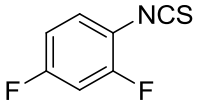
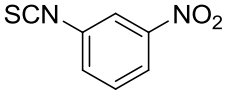
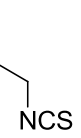
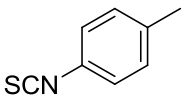
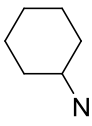
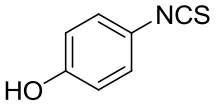
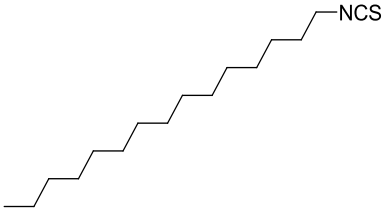
Code	Isothiocyanates	Code	Isothiocyanates
PRO1	 Phenyl Isothiocyanate	PRO6	 2-Iodo-4- Methylphenyl Isothiocyanate
PRO2	 2-Chlorophenyl Isothiocyanate	PRO7	 2, 4-Difluorophenyl Isothiocyanate
PRO3	 3-Nitrophenyl Isothiocyanate	PRO8	 Butyl Isothiocyanate
PRO4	 4-Methylphenyl Isothiocyanate	PRO9	 Cyclohexyl Isothiocyanate
PRO5	 4-Hydroxyphenyl Isothiocyanate	PRO10	 Tetradodecyl Isothiocyanate

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Table 3: Grid set for docking simulation

Target protein (pdbid)	Cavity	Centre	Radius
3ppo	volume- 105.98Å^3, surface- 303.36Å^2	X: -1.55, Y: 34.18, Z: 6.29	12Å
1gii	volume- 138.24 Å^3, surface- 392.96 Å^2	X: 8.20, Y: 11.04, Z: 26.72	12Å
2vcj	volume- 127.488 Å^3, surface- 327.68Å^2	X: 33.21, Y: 8.40, Z: -24.43	8Å
3sao	volume- 424.448 Å^3, surface- 926.72 Å^2	X: -3.02, Y: 1.57, Z: -17.33	12Å

Drug-likeliness and ADMET predictions

In this study Lipinski rule of five for predicting the drug likeliness of a molecule are applied to the isothiocyanates (Lipinski, 2004). Prediction of significant descriptors for ADMET properties of the compounds were done using admetSAR server (http://lmmd.ecust.edu.cn/admetsar1/) (Feixiong *et al.*, 2012).

Docking computation

Docking studies of the isothiocyanate compounds were performed using Molegro Virtual Docker (MVD) software. The 3 dimensional (3D) structure of the target enzyme/protein was then imported into the MVD and the cavities or binding sites were predicted and the one with the highest volume was selected for consideration (Kusumaningrum *et al.,* 2014) The grid set aside for each individual docking studies surrounding the region of interest (active binding site) in the target enzyme/protein are given in table 3. The isothiocyanate compounds were docked against the target enzyme/protein and independent runs (Table 3) were performed for each of the isothiocyanate compounds with maximum number of five poses returned based on a differential evolution search algorithm. The docking energy scoring function was based on the modified piecewise linear potential (PLP) with new hydrogen bonding and electrostatic terms included (Thomsen and Christensen, 2006). The best pose of each compound with the highest re-rank score was selected for subsequent ligand-protein interaction energy analysis.

Results and Discussion

Drug-likeliness and ADMET analysis

The drug-likeness parameters predicted are shown in table 4, the isothiocyanates understudy fulfill all the criteria's of being a lead compound revealing that these compounds does not violate the Lipinski rule of five to be an orally active compounds.

The relative ADMET profiles of the isothiocyanates as obtained from admetSAR server are shown in table 5. The BBB permeability of all the isothiocyanate molecules understudy was predicted to have good permeability. Similarly, the Caco-2 and HIA describing the intestinal absorption of the compounds. PRO1 and PRO2 were predicted to be toxic and carcinogenic amongst all the other candidates whereas the other were non-carcinogenic.

Table 4: Drug likeliness parameters by applying Lipinski Rule of five.

Ligand	MW[1]	HBD[2]	HBA[3]	LogP[4]	TPSA[5]
PRO1	135.190 g/mol	0	1	2.907	44.45 Å
PRO2	169.635 g/mol	0	1	3.513	44.45 Å
PRO3	180.187 g/mol	0	4	1.9854	90.27 Å
PRO4	149.217 g/mol	0	1	3.2509	44.45 Å
PRO5	151.189 g/mol	1	2	2.5613	64.68 Å
PRO6	275.109 g/mol	0	1	3.688	44.45 Å
PRO7	171.170 g/mol	0	2	3.1086	44.45 Å

PRO8	115.199 g/mol	0	1	2.908	44.45 Å
PRO9	141.237 g/mol	0	1	3.1486	44.45 Å
PRO10	269.495 g/mol	0	1	7.9064	44.45 Å

(1) MW: Molecular weight > 500. (2) HBD: Hydrogen bond donor > 5. (3) HBA: Hydrogen bond acceptor > 10. (4) logP > 5. (5) PSA: Topological polar surface area ≥ 140Å.

Table 5: ADMET profile obtained from admetSAR server.

Ligand	BBB[a] Probability	HIA[b] Probability	Caco-2[c] Probability	Ames test[d]	Acute Oral Toxicity (kg/mol)
PRO1	0.9915	0.9905	0.8538	Positive	2.224
PRO2	0.9832	0.9905	0.8745	Negative	2.847
PRO3	0.9757	0.9521	0.8459	Negative	1.702
PRO4	0.9923	0.9956	0.9956	Negative	2.563
PRO5	0.9642	0.9898	0.8271	Negative	2.380
PRO6	0.9625	0.7360	0.6904	Negative	2.608
PRO7	0.9839	0.9903	0.7028	Positive	2.981
PRO8	0.9646	0.9642	0.6788	Negative	2.807
PRO9	0.9405	0.8576	0.6144	Negative	2.647
PRO10	0.9619	0.9602	0.6256	Negative	2.551

(a)BBB: Blood Brain Barrier; value closer to 1 represents better permeability through BBB. (b) HIA: Human Intestinal Permeability; value closer to 1 represents better absorption through intestine. (c) Caco-2: Human Intestinal Cell Line used for in-silico simulation. (d) AMES Test: A positive toxicity indicates the molecule for being a probable mutagen..

Molecular docking analysis
Oral cancer

With 3ppo as target

The compatible solute ATP-binding cassette (ABC) transporters are indispensable for acquiring a variety of compatible solutes under osmotic stress in *Bacillus subtilis*. The substrate-binding protein OpuCC of the ABC transporter OpuC can recognize a broad spectrum of compatible solutes, compared to its 70% sequence-identical paralog OpuBC that can solely bind choline. OpuCC is composed of two alpha/beta/alpha globular sandwich domains linked by two hinge regions, with substrate-binding pocket located at the inter-domain cleft. Upon substrate-binding, the two domains shift towards each other to trap the substrate. This attributes to the multiple-substrate binding property making it a therapeutic target (Du *et al.,* 2011**).**

Molecular docking studies were carried out using Molegro Virtual Docker (MVD) to understand the mode of binding of the isothiocyanate molecules understudy with the target protein kinase domain of HER2 Protein (pdb id: 3ppo) with Mehtoxtrate and Cisplatin as reference drugs. The docking hits result showed that all the compounds under study except PRO2 were found to be docked at the binding cavity of the target and presented favorable binding affinities ranging from -65.93 kcal/mol to -134.10 kcal/mol as shown in table 6 with compound PRO10 presenting the best docking score of -110.81 kcal/mol comparable to the score of Methoxtrate and better than the score of Cisplatin. The molecular interaction between the ligands and the target are illustrated in table 7. The docking hits showed common interaction with Asn135, Asn170, Thr219 and and Tyr137 residues of the target enzyme. This showed that the compounds interacted with the residues that are considered to be involved in the active site (Figure 1) common to the reference drugs interaction causing possible mutations hindering the functioning of the protein. These interactions study reveals the compounds understudy as promising inhibitors. The snapshots of ligand-protein interactions showing the binding mode are shown in figure 2.

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Table 6: Molecular docking score of the ITCs and reference drugs with 3ppo

Ligand	MolDock Score	Rerank Score	Interaction	Internal	HBond	LE1	LE3
PRO10	-129.52	-103.53	-134.10	4.58	-1.55	-7.20	-5.75
Methotrexate	-140.99	-95.49	-190.37	49.38	-9.05	-4.27	-2.89
PRO3	-91.37	-79.17	-103.09	11.72	-2.99	-7.61	-6.60
PRO5	-81.88	-69.17	-91.64	9.76	-6.41	-8.19	-6.92
PRO7	-79.64	-67.55	-91.18	11.54	-2.73	-7.24	-6.14
PRO4	-78.61	-66.38	-88.35	9.74	-3.84	-7.86	-6.64
PRO6	-79.10	-65.49	-87.11	8.02	-0.72	-7.19	-5.95
PRO2	-78.28	-64.94	-87.33	9.04	0.00	-7.83	-6.49
PRO9	-75.97	-64.89	-78.72	2.75	-1.44	-8.44	-7.21
PRO1	-71.61	-61.68	-82.13	10.52	-1.23	-7.96	-6.85
PRO8	-66.88	-56.50	-65.93	-0.95	-1.65	-9.55	-8.07
Cisplatin	-70.57	-51.09	-70.57	0.00	-0.69	-14.11	-10.22

Where,*Rerank Score*:The rerank score is a linear combination of E_{inter} (steric, Van der Waals, hydrogen bonding, electrostatic) between the ligand and the protein and E_{intra} (torsion, sp2-sp2, hydrogen bonding, Van der Waals, electrostatic) of the ligand.
Interaction:The total interaction energy between the pose and the protein (kJ/mol).
Internal: The internal energy of the pose.
HBond: Hydrogen bonding energy (kJ/mol).
LE1: Ligand efficiency 1: MolDock score divided by heavy atoms count.
LE3: Ligand efficiency 3: Rerank score divided by heavy atoms count.

Table 7: Molecular interaction analysis of ITCs and reference drugs at the active site of 3ppo

Ligand	Interaction (Protein-Ligand)	Interaction Distance (Å)	Interaction Energy (kJ/mol)	Hybridization of Protein atom	Hybridization of ligand atom
PRO10	Asn 170(N)....N(15)	3.14	-1.5	sp^2(Donor)	sp^2(Acceptor)
Methotrexate	Asn 135(O)....N(6)	2.57	-2.2	sp^2(Acceptor)	sp^3(Donor)
	Thr 94(OGI)....N(5)	3.19	-2.04	sp^3(both)	sp^2(Acceptor)
	Thr 94(OGI)....N(9)	39	-1.2	sp^3(both)	sp^2(Acceptor)
	Tyr 137(OH)....N(5)	1.96	-1.7	sp^3(both)	sp^2(Acceptor)
	Tyr 137(OH)....N(9)	2.64	-2.5	sp^3(both)	sp^2(Acceptor)
	Tyr 217(OH)....N(8)	3.57	-0.14	sp^3(both)	sp^2(Acceptor)
	Ile 199(N)....O(31)	3.13	-0.06	sp^2(Donor)	sp^2(Acceptor)
	Gly200(N)....O(31)	2.74	-2.5	sp^2(Donor)	sp^2(Acceptor)
	Asn 170(N)....O(23)	3.23	-1.7	sp^2(Donor)	sp^2(Acceptor)
	Ser 40(OG)....H(53)	1.19	-2.5	sp^3(both)	sp^3(Donor)
PRO3	Asp 220(N)....O(7)	2.92	-0.003	sp^2(Donor)	sp^2(Acceptor)
	Thr 219(N)....O(7)	3.46	-0.28	sp^2(Donor)	sp^2(Acceptor)
	Thr 219(OGI)....O(7)	2.56	-2.2	sp^3(both)	sp^2(Acceptor)
	Thr 219(OGI)....N(6)	3.24	-1.8	sp^3(both)	sp^3(Acceptor)
	Asn 135(ND2)..N(6)	3.1	-2.5	sp^2(Donor)	sp^3(Acceptor)

PRO5	Thr 42(N)....N(7)	3.23	-1.4	sp^2(Donor)	sp^2(Acceptor)
	Thr 219(OGI)....O(6)	2.63	-2.5	sp^3(both)	sp3(both)
	Glu 43(OEI)....O(6)	7.15	-2.5	sp^2(Acceptor)	sp^2(both)
	Asn 278(ND2)..O(6)	2.67	-2.5	sp^2(Donor)	sp^2(both)
PRO7	Thr 42(OGI)....N(0)	3.4	-0.9	sp^3(both)	sp^2(Acceptor)
	Thr 42(N)....N(8)	2.78	-2.14	sp^2(Donor)	sp^2(Acceptor)
PRO4	Thr 42(OGI)....N(7)	3.06	-2.5	sp3(both)	sp^2(Acceptor)
	Thr 42(N)....N(7)	3.15	-2.2	sp^2(Donor)	sp^2(Acceptor)
PRO6	Gln 39(NE2)....N(8)	3.23	-1.8	sp^2(Donor)	sp^2(Acceptor)
PRO2	Thr 94(OGI)....N(7)	2.83	-2.5	sp3(both)	sp^2(Acceptor)
PRO9	Thr 92(N)....N(6)	3.27	-1.4	sp^2(Donor)	sp^2(Acceptor)
PRO1	Thr 42(N)....N(6)	2.9	-1.2	sp^2(Donor)	sp^2(Acceptor)
PRO8	Thr 42(N)....N(4)	3.05	-1.6	sp^2(Donor)	sp^2(Acceptor)
Cisplatin	Tyr 203(OH)....N(2)	2.9	-2.5	sp^3(both)	sp^3(Donor)
	Asp 220(ODI)..N(2)	2.56	-2.1	sp^3(Acceptor)	sp^3(Donor)
	Asp 220(ODI)..N(4)	3.08	-1.8	sp^3(Acceptor)	sp^3(Donor)
	Asp 282(ODI)...N(4)	2.83	-2.5	sp^3(Acceptor)	sp^3(Donor)

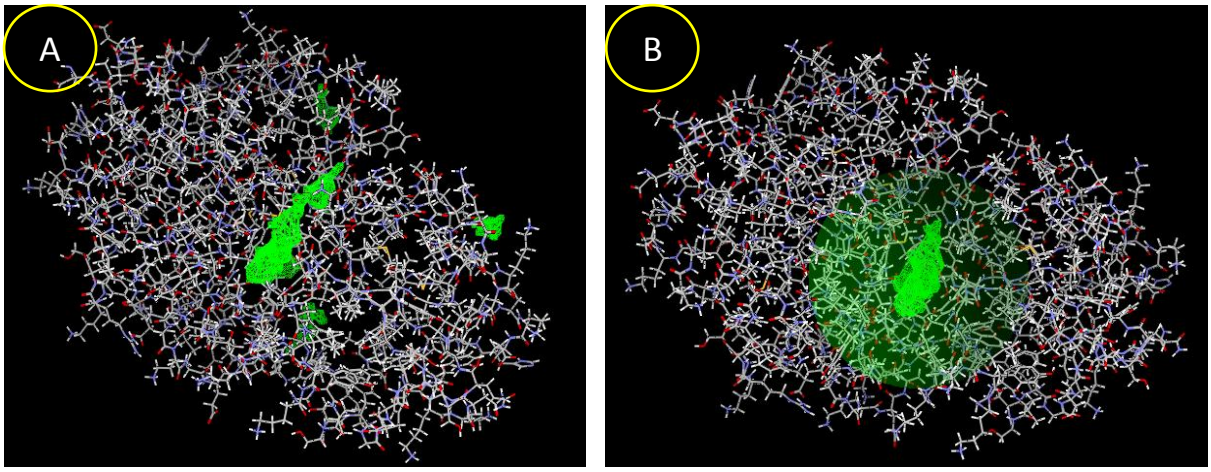

Figure 1: A: predicted cavities of 3ppo (green) ; B: selected cavity (green sphere) for molecular docking studies

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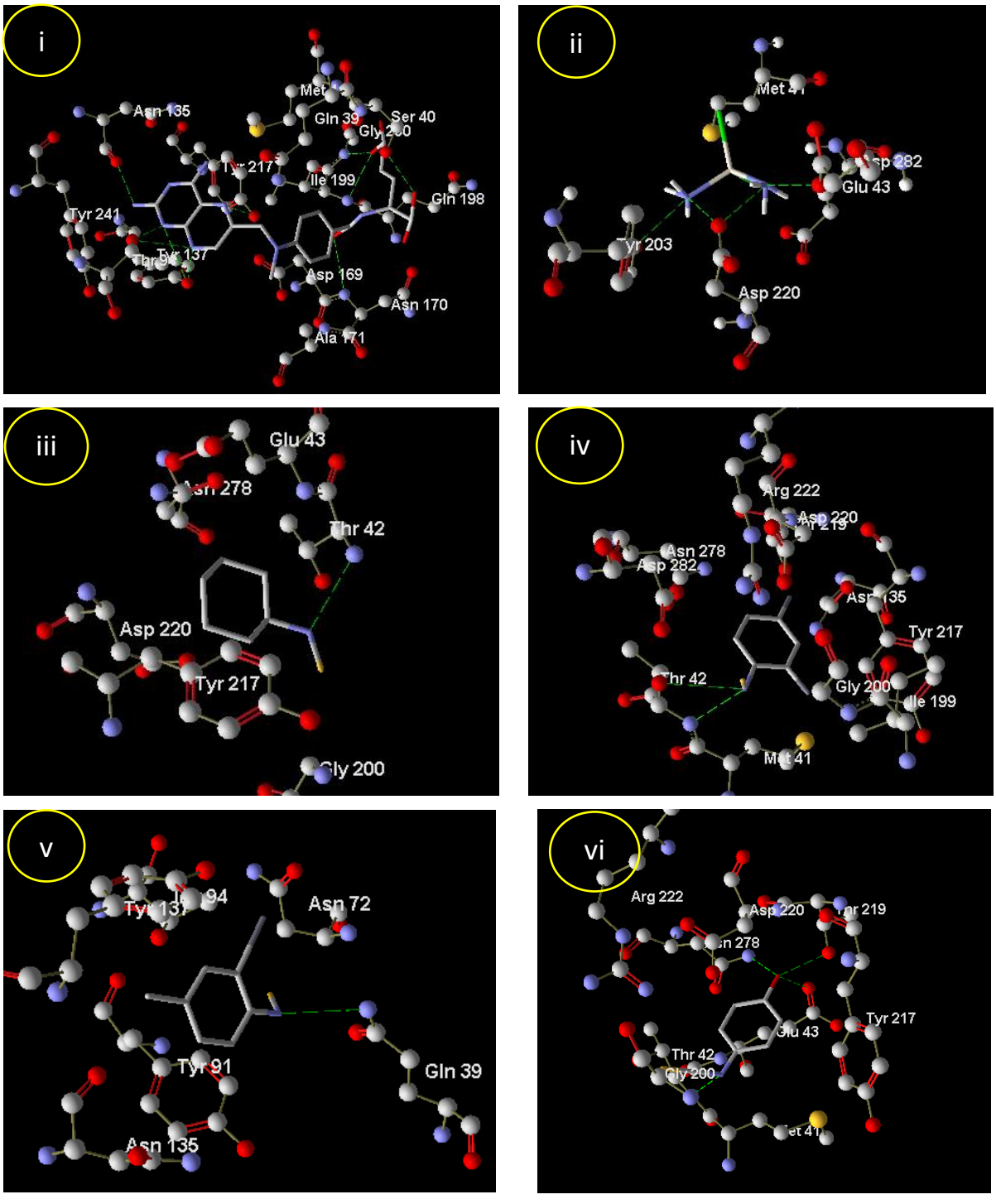

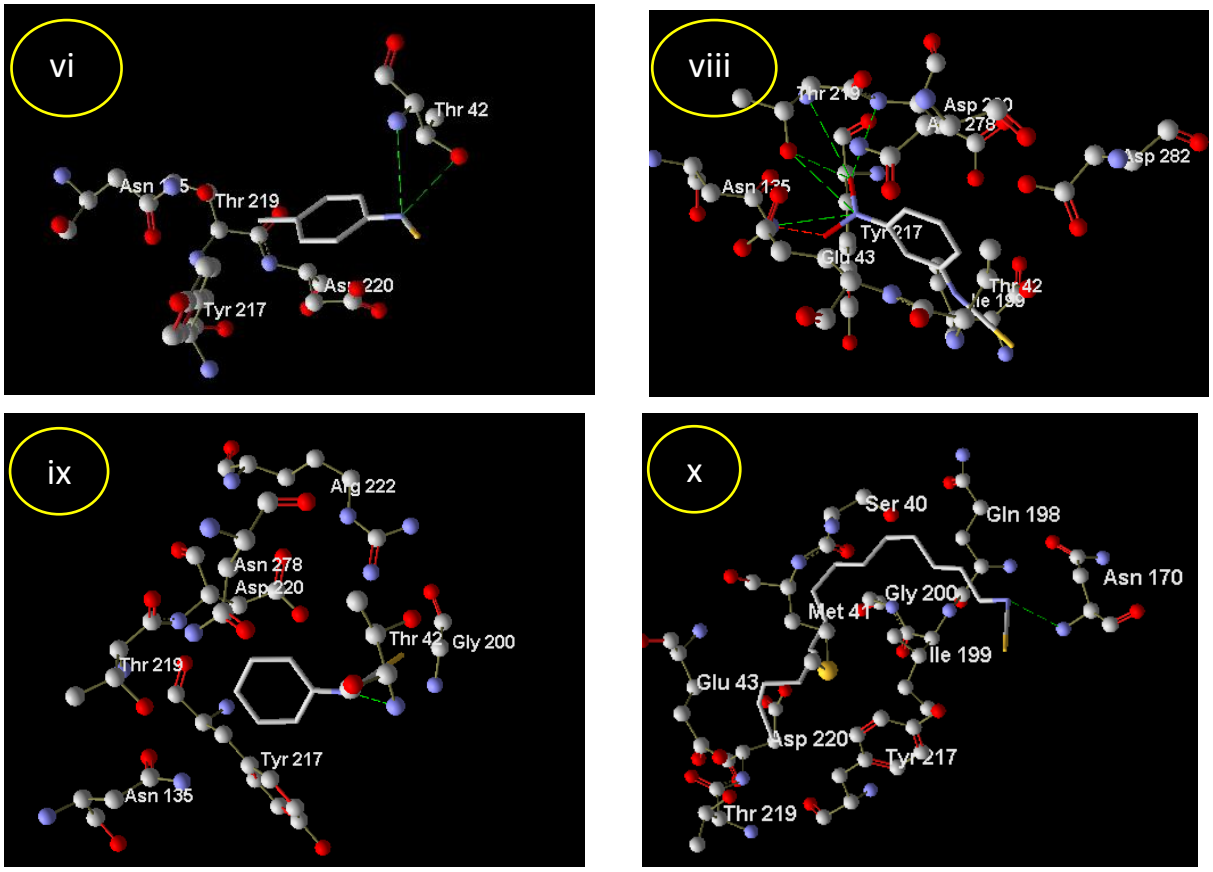

Fig 2: Molecular interaction of (i) Methoxtrate, (ii) Cisplatin, (iii)PRO1, (iv)PRO3, (v) PRO4, (vi)PRO5, (vii) PRO6, (viii) PRO7, (ix) PRO9, (x) PRO10; at the active site of 3ppo

With 1gii as target

Cyclin dependent kinases are critical molecules that control cell cycle progression from one phase to the other. However, mutational changes in these molecules lead to the purturbed cell cycle leading to uncontrolled cellular proliferation or cell death. In humans, mutations in cyclin dependent kinase 2 (1GII) is responsible for nearly 50% of cancers. (Sanghani *et al.*, 2012). Therefore Cyclin dependent kinases can be a therapeutic target for oral cancers.

To understand the mode of binding of the isothiocyanate molecules understudy with the target protein Cyclin Dependent Kinase 2 (pdb id: 1gii) with Mehtoxtrate and Cisplatin as reference drugs. The docking hits result showed that PRO2, PRO3, PRO4, PRO5, PRO7 and PRO8 docked at the binding cavity of the target and presented favorable binding affinities shown in table 8 comparable to the score of Methoxtrate and better than the score of Cisplatin. The molecular interaction between the ligands and the target are illustrated in table 9. The docking hits showed common interaction with Asp145 and and Lys129 residues of the target enzyme. This showed that the compounds interacted with the residues that are considered to be involved in the active site (Figure 3) common to the reference drugs interaction hindering the functioning of the protein. This results reveals that these compounds can pose as a promising candidate for oral cancers targeting the Cyclin Dependent Kinase 2. The snapshots of ligand-protein interactions showing the binding mode are shown in figure 4.

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Table 8: Molecular docking score of the ITCs and reference drugs with 1gii

Ligand	MolDock Score	Rerank Score	Interaction	Internal	HBond	LE1	LE3
Methotrexate	-122.17	-92.06	-165.40	43.23	-10.89	-3.70	-2.79
PRO10	-102.68	-81.93	-100.54	-2.14	0	-5.70	-4.55
PRO5	-66.37	-55.91	-76.79	10.41	-4.03	-6.64	-5.59
PRO3	-68.73	-55.66	-80.07	11.34	-6.44	-5.72	-4.63
PRO7	-68.90	-52.95	-80.54	11.64	-3.51	-6.26	-4.81
PRO9	-58.60	-51.82	-63.94	5.33	0	-6.51	-5.75
PRO4	-64.39	-50.22	-73.76	9.37	-5.48	-6.43	-5.02
PRO1	-58.48	-49.68	-69.26	10.78	0	-6.49	-5.52
PRO6	-58.68	-49.11	-67.15	8.47	0	-5.33	-4.46
PRO2	-60.05	-48.29	-70.40	10.34	-0.37	-6.01	-4.82
PRO8	-54.75	-46.17	-55.01	0.26	-2.93	-7.82	-6.59
Cisplatin	-40.53	-37.58	-40.53	0	-4.10	-8.10	-7.51

Table 9: Molecular interaction analysis of ITCs and reference drugs at the active site of 1gii

Ligand	Interaction (Protein-Ligand)	Interaction Energy (kJ/mol)	Interaction Distance (Å)	Hybridization of Protein atom	Hybridization of ligand atom
Methotrexate	Ile 10(O).....N(0)	-2.5	2.87	sp^2 (Acceptor)	sp^2 (Donor)
	His 82(NE2).....N(6)	-2.5	3.06	sp^2 (Acceptor)	sp^3(Donor)
	Val 83(O).....N(6)	-2.5	2.72	sp^2 (Acceptor)	sp^3 (Donor)
	Val 83(O).....O(32)	-1.5	3.29	sp^2 (Acceptor)	sp^3 (both)
	Val 83(N).....O(32)	-2.5	2.92	sp^2 (Acceptor)	sp^3 (both)
	Asp 145(N).....O(29)	-0.378	3.44	sp^2 (Donor)	sp^3 (both)
PRO5	Asp 145(OD2)....O(6)	-0.13	3.57	sp^2 (Acceptor)	sp^3 (both)
	Tyr 15(N)....O(N)	-2.5	2.97	sp^2 (Donor)	sp^3 (both)
	Lys 33(NZ).....O(6)	-2.5	2.97	sp^3 (Donor)	sp^3 (both)
PRO3	Thr 14(N)....N(6)	-1.74	3.25	sp^2 (Donor)	sp^3 (Acceptor)
	Thr 14(OG1)....O(8)	-2.5	2.79	sp^3 (both)	sp^2 (Acceptor)
	Lys 129(NZ)....N(6)	-0.02	3.59	sp^3 (Donor)	sp3(Acceptor)
	Lys 129(NZ)....O(9)	-2.5	3.06	sp^3 (Donor)	sp^2 (Acceptor)
PRO7	Thr 14(N).....N(8)	-1.01	3.24	sp^2 (Donor)	sp^2 (Acceptor)
	Tyr 15(N).....N(8)	-2.5	3.09	sp^2 (Donor)	sp^2 (Acceptor)
PRO4	Thr 14(N)....N(7)	-0.48	3.18	sp^2 (Donor)	sp^2 (Acceptor)
	Tyr 15(N)....N(7)	-2.5	2.85	sp^2 (Donor)	sp^2 (Acceptor)
	Lys 33(NZ)....N(7)	-2.5	3.09	sp^3 (Donor)	sp^2 (Acceptor)
PROD2	Ala 149(N)....N(7)	-0.3	3.26	sp^2 (Donor)	sp^2 (Acceptor)
PRO8	Tyr 15(N)....N(4)	-0.99	3.4	sp^2 (Donor)	sp^2 (Acceptor)
	Thr 14(N)....N(4)	-1.93	3.02	sp^2 (Donor)	sp^2 (Acceptor)
Cisplatin	Asp 127(OD2)...N(2)	-2.5	2.88	sp^2 (Acceptor)	sp^3 (Donor)
	Asp 127(OD2)...N(4)	-2.3	3.14	sp^2 (Acceptor)	sp^3 (Donor)
	Asp 145(OD2)...N(4)	-2.5	2.95	sp^2 (Acceptor)	sp^3 (Donor)

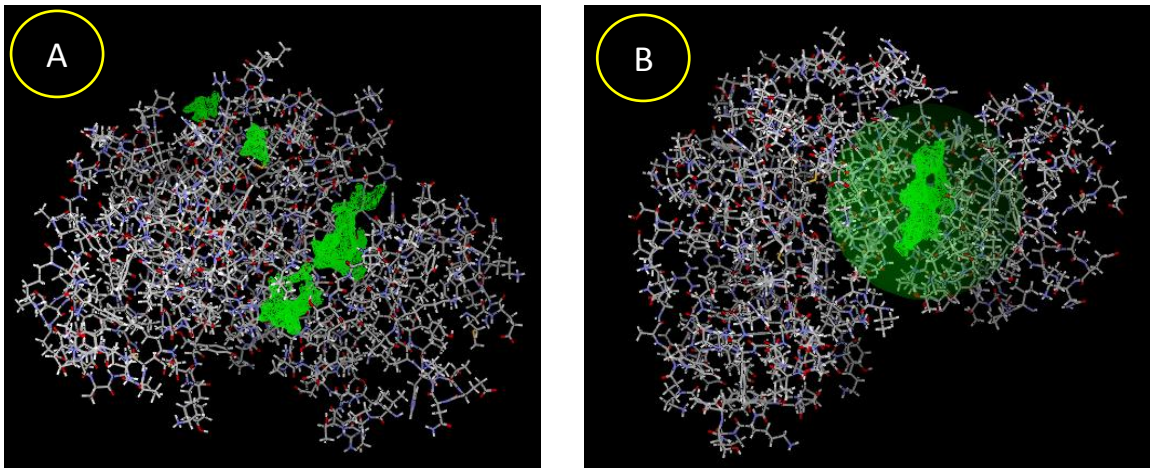
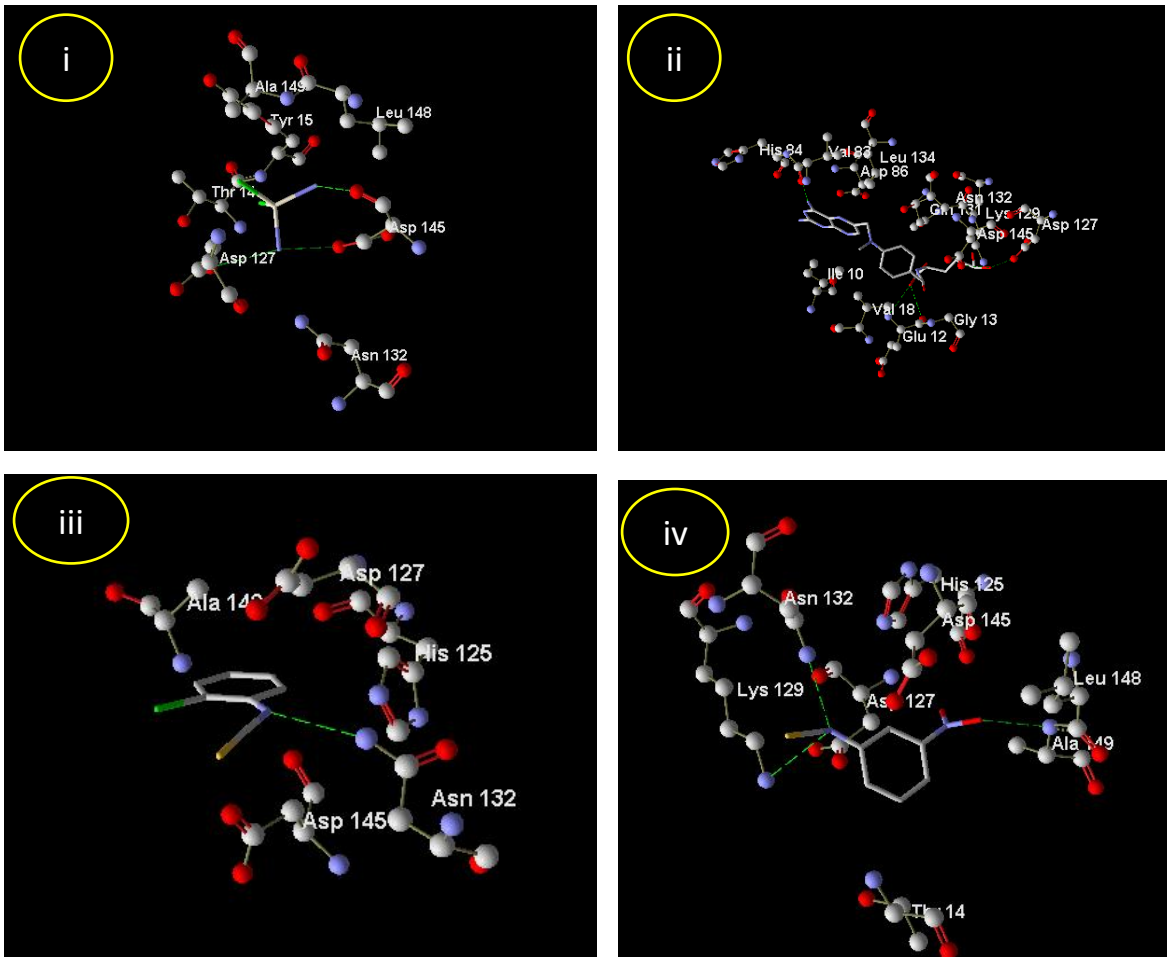


Figure 3: A: predicted cavities of 1gii (green) ; B: selected cavity (green sphere)for molecular docking studies



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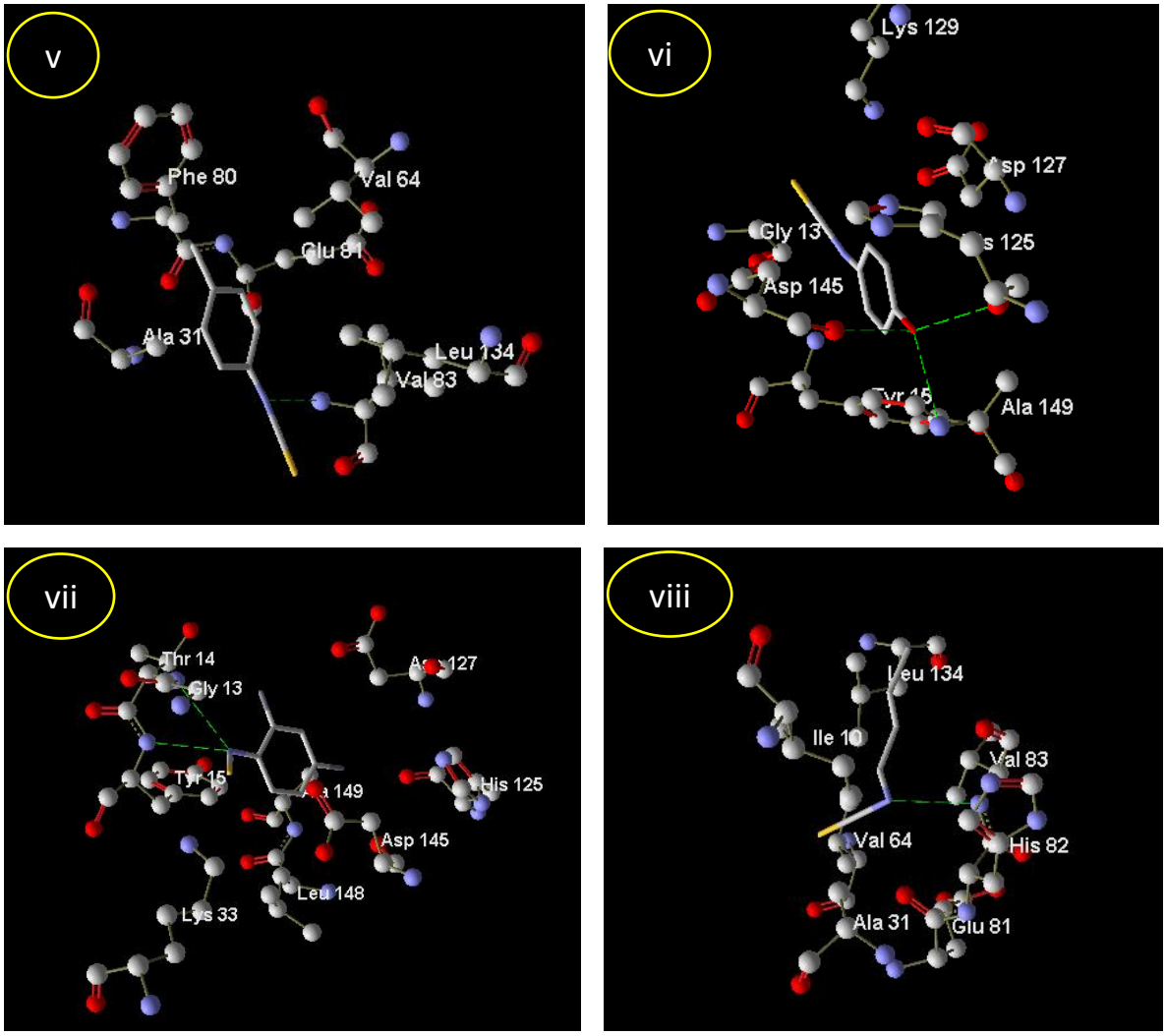

Fig 4: Molecular interaction of (i) Cisplatin, (ii)Methoxtrate, (iii)PRO2, (iv)PRO3, (v) PRO4, (vi)PRO5, (vii) PRO7, (viii) PRO8; at the active site of 1gii

Skin cancer

With 2vcj as target

The protein Hsp90 is abundant in eukaryotic cells and its expression increases when cells are exposed to a variety of stresses. Hsp90 contains three conserved domains: an N-terminal ATP-binding domain, a middle domain, and a carboxy-terminal domain. Hsp90 is upregulated 10fold in tumour cells suggesting that it helps maintaining tumour cell growth and/or survival. Another role for Hsp90 in the maintenance of tumour cells is its ability to inhibit apoptosis. Inhibitors of the Hsp90 molecular chaperone are showing considerable promise as potential chemotherapeutic agents for cancer (Zuehlke and Johnson, 2010).

Molecular docking combined with a scoring function can be used to quickly screen large databases of potential drugs *in silico* to identify molecules that are likely to bind to protein target of interest. A binding interaction between a small molecule ligand and an enzyme protein may result in activation or inhibition of the enzyme. Therefore, ITCs were docked with the Hsp90 chaperone and the results revealed that all the ITCs understudy except PRO8 docked at the binding cavity (Figure 5) of the target and presented favourable binding affinities shown in table 10 comparable to the score of Erivedge and Aldara. PRO10 showed the best candidate. The molecular interaction between the ligands and the target are illustrated in table 11 and ligand-protein interactions showing the binding mode are shown in figure 6.

Table 10: Molecular docking score of the ITCs and reference drugs with 2vcj

Ligand	MolDock Score	Rerank Score	Interaction	Internal	HBond	LE1	LE3
PRO10	-101.95	-76.87	-101.58	-0.36	-0.12	-5.66	-4.27
Erivedge	-96.71	-75.39	-118.26	21.54	-2.49	-3.58	-2.79
Aldara	-87.32	-69.42	-98.07	10.75	-0.02	-4.85	-3.86
PRO3	-69.45	-60.75	-81.30	11.85	-2.40	-5.79	-5.06
PRO6	-66.09	-55.50	-73.80	7.71	-0.24	-6.01	-5.05
PRO7	-62.87	-54.71	-74.23	11.36	-0.25	-5.72	-4.97
PRO9	-58.26	-52.46	-61.01	2.75	0.00	-6.47	-5.83
PRO5	-59.32	-51.64	-68.57	9.25	-3.55	-5.93	-5.16
PRO2	-58.73	-51.26	-67.82	9.09	-0.27	-5.87	-5.13
PRO4	-58.05	-50.55	-67.46	9.40	-0.26	-5.81	-5.06
PRO1	-50.94	-46.29	-61.62	10.68	-0.25	-5.66	-5.14
PRO8	-52.12	-45.23	-51.40	-0.72	0.00	-7.45	-6.46

Table 11: Molecular interaction analysis of ITCs and reference drugs at the active site of 2vcj

Ligand	Interaction (Protein-Ligand)	Interaction Energy (kJ/mol)	Interaction Distance (Å)	Hybridization of Protein atom	Hybridization of ligand atom
PRO10	Asn51(ND2)...N(15)	-1.8	3.22	sp^2(Donor)	sp^2(Acceptor)
	Lys 58(NZ)....O(8)	-2.4	3.1	sp^3(Donor)	sp^2(Acceptor)
Erivedge	Asn51(O)---N(12)	-0.62	2.78	sp^2(Acceptor)	sp^2(Donor)
	Val186(N)----O(9)	-0.10	3.1	sp^2(Donor)	sp^2(Acceptor)
Aldara	Asn 51(ND2)....N(8)	-0.4	3.52	sp^2(Donor)	sp^2(Acceptor)
	Lev 107(O)....H(23)	-2	3.01	sp^2(Acceptor)	sp^3(Donor)
PRO3	Ser 52(OG)....N(6)	-2.5	2.92	sp^3(both)	sp^3(Acceptor)
	Asn 51(ND2)....N(9)	-2.3	1.96	sp^2(Donor)	sp^2(Acceptor)
PRO6	Ser 52(N)....N(8)	-0.2	3.28	sp^2(Donor)	sp^2(Acceptor)
	Ser 52(OG)....N(8)	-0.12	3.58	sp^3(both)	sp^2(Acceptor)
PRO7	Ser 52(N)....N(8)	-0.2	3.27	sp^2(Donor)	sp^2(Acceptor)
	Ser 52(OG)....N(8)	-0.2	3.56	sp^3(both)	sp^2(Acceptor)
PRO5	Ser 52(N)....O(6)	-1.04	3.08	sp^2(Donor)	sp^3(both)
	Ser 52(OG)....O(6)	-2.5	2.72	sp^3(both)	sp^3(both)
	Lev 48(O)....H(14)	-2.5	1.86	sp^2(Acceptor)	sp^3(Donor)
PRO2	Ser 52(N)....N(7)	-0.26	3.35	sp^2(Donor)	sp^2(Acceptor)
PRO4	Ser 52(N)....N(7)	-0.26	3.23	sp^2(Donor)	sp^2(Acceptor)
PRO1	Ser 52(N)....N(6)	-0.24	3.28	sp^2(Donor)	sp^2(Acceptor)

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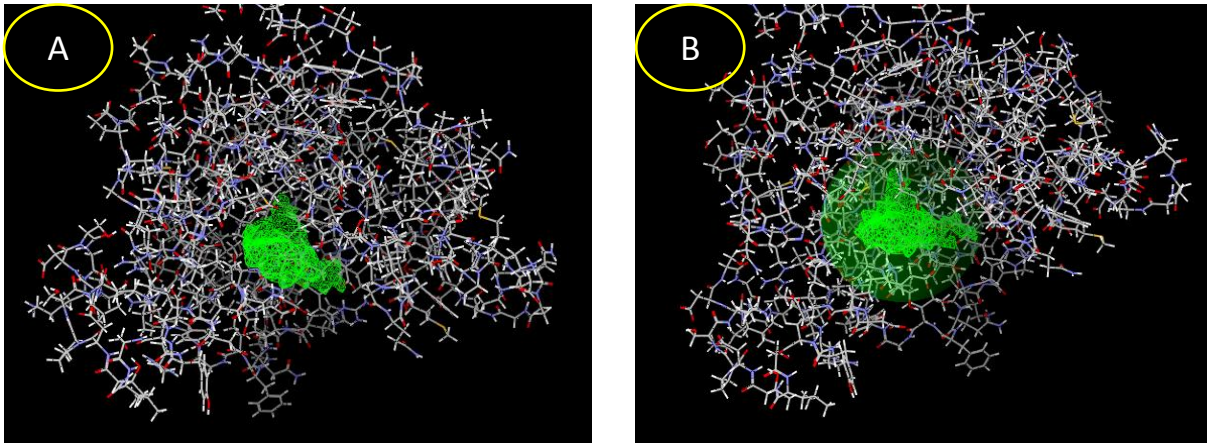
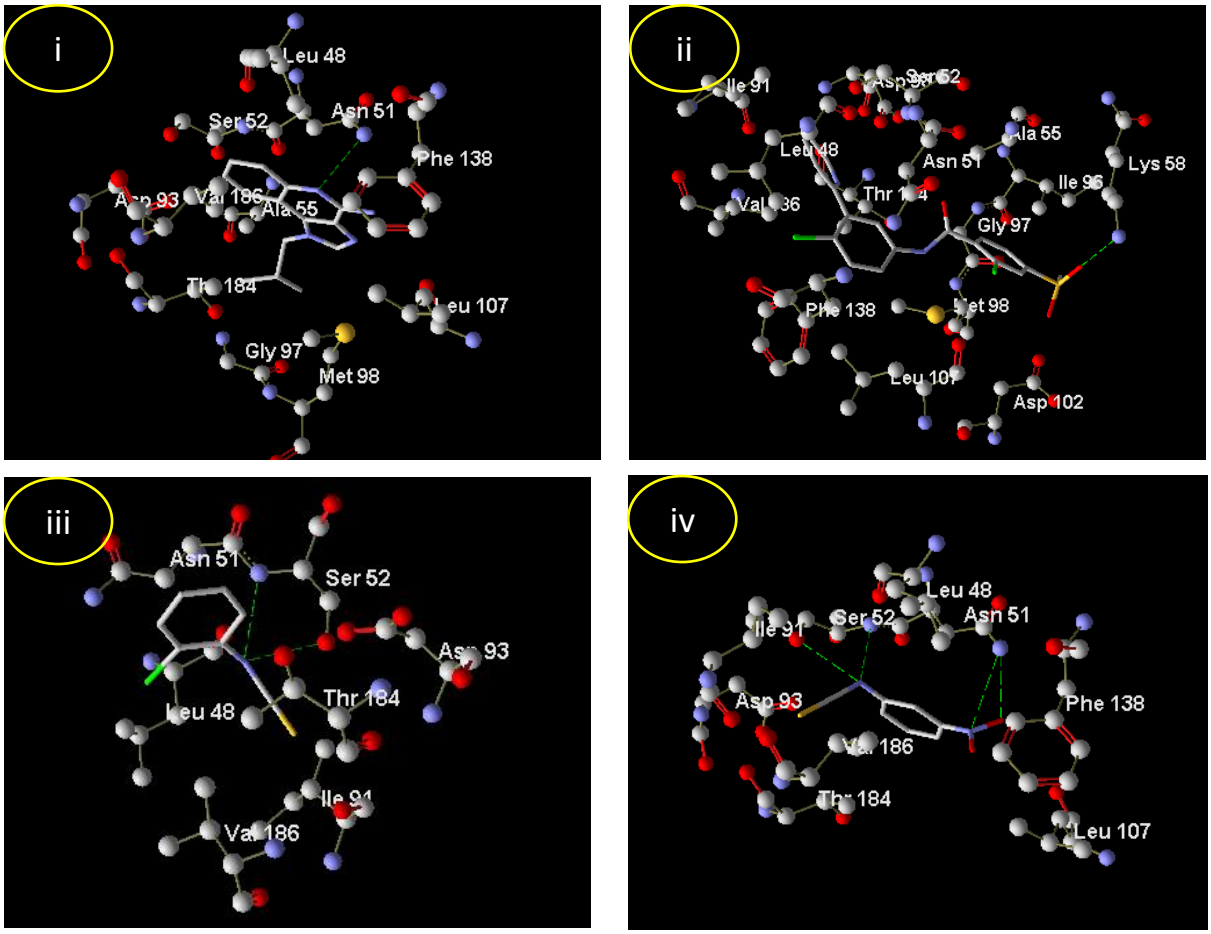


Figure 5: A: predicted cavities of 2vcj (green) ; B: selected cavity (green sphere)for molecular docking studies



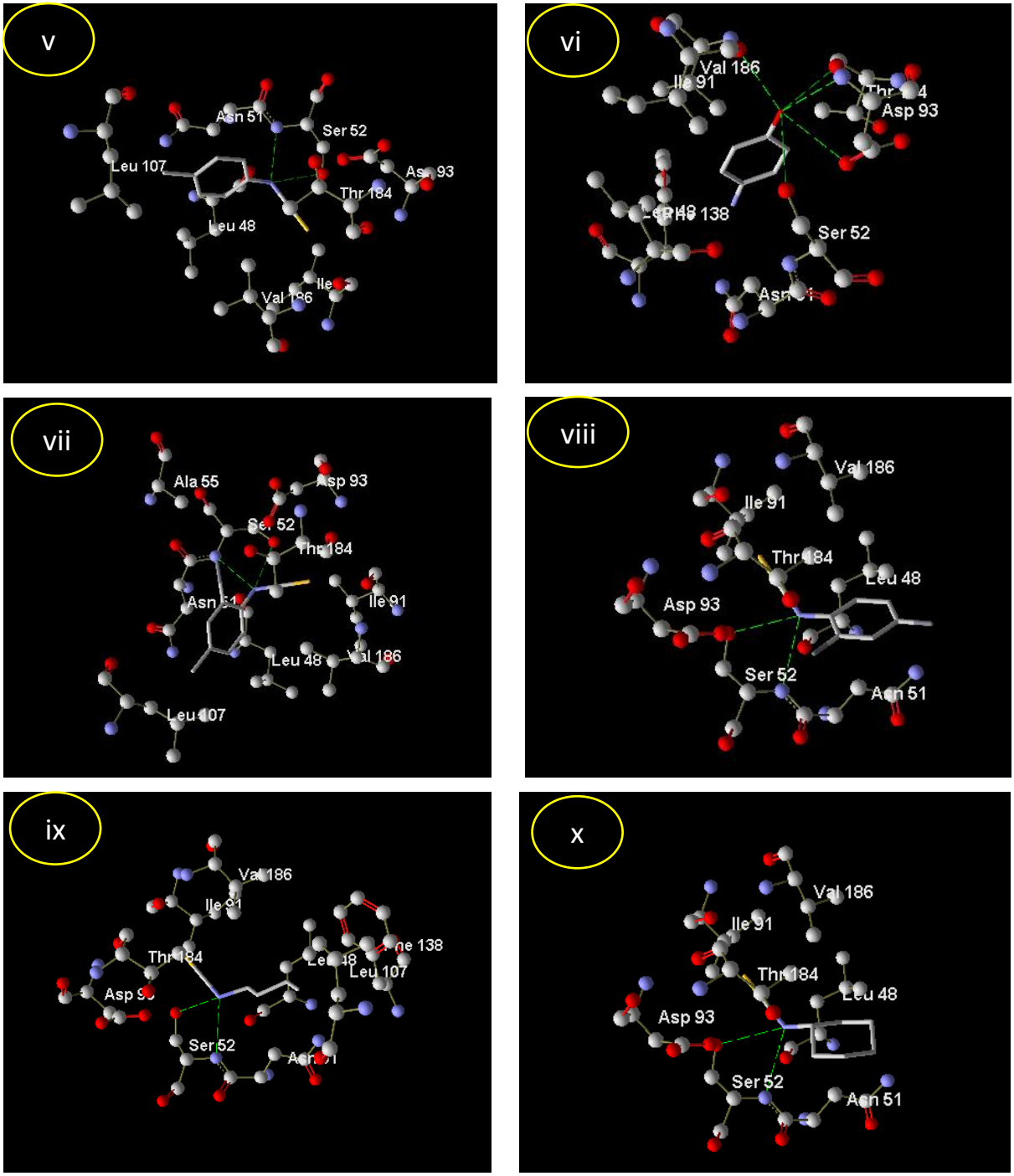


Fig 6: Molecular interaction of (i) Aldara, (ii)Erivedge, (iii)PRO2, (iv)PRO3, (v) PRO4, (vi)PRO5, (vii) PRO6, (viii) PRO7, (ix) PRO8, (x) PRO9; at the active site of 2vcj

With 3sao as target

Growth arrest assays functionally confirm the bacteriostatic effect of Ex-FABP in vitro under iron-limiting conditions. The 1.8 Å crystal structure of Ex-FABP explains the expanded specificity, but also surprisingly reveals an extended, multi-chambered cavity extending through the protein and encompassing two separate ligand specificities, one for bacterial siderophores (as in Siderocalin) at one end and one specifically binding copurified lysophosphatidic acid, a potent cell signaling molecule, at the other end, suggesting Ex-FABP employs dual functionalities to explain its diverse endogenous activities making it a therapeutic target (Correnti *et al.*, 2011)

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The binding mode of the ITCs were studied through molecular docking. The results revealed that the ITCs bind to the predicted cavities with binding affinities ranging from -55.76 kcal/mol to -101.37 kcal/mol as shown in table 12. The docking hits showed common interactions to that of reference drugs Erivedge and Aldara through the amino acid residue Lys 32 (Table 13) with PRO10 as the top candidate comparable to the reference drugs. This shows that ITCs can interact at the active site (figure 7) of the target protein thereby altering its functioning. The mode of binding of the ITCs with the protein are shown in figure 8.

Table 12: Molecular docking score of the ITCs and reference drugs with 3sao

Ligand	MolDock Score	Rerank Score	Interaction	Internal	HBond	LE1	LE3
ERIVEDGE	-110.44	-82.87	-132.76	22.33	-0.75	-4.09	-3.07
PROD10	-100.47	-81.23	-101.37	0.90	0.00	-5.58	-4.51
ALDARA	-101.84	-80.24	-113.02	11.18	-3.17	-5.66	-4.46
PRO3	-78.35	-66.94	-89.86	11.51	-2.50	-6.53	-5.58
PROD7	-72.95	-60.52	-84.33	11.38	0.00	-6.63	-5.50
PROD6	-76.27	-59.01	-84.05	7.78	-2.50	-6.93	-5.36
PROD2	-70.40	-58.16	-79.45	9.04	-2.10	-7.04	-5.82
PROD5	-68.47	-57.27	-77.74	9.27	-4.17	-6.85	-5.73
PROD4	-68.48	-57.05	-77.76	9.29	-2.50	-6.85	-5.70
PRO1	-62.10	-53.14	-72.81	10.72	-2.49	-6.90	-5.90
PRO9	-63.38	-52.11	-66.24	2.86	-2.50	-7.04	-5.79
PRO8	-57.47	-47.59	-55.76	-1.71	-2.13	-8.21	-6.80

Table 13: Molecular interaction analysis of ITCs and reference drugs at the active site of 3sao

Ligand	Interaction (Protein-Ligand)	Interaction Energy (kJ/mol)	Interaction Distance (Å)	Hybridization of Protein atom	Hybridization of ligand atom
Erivedge	Lys 32(N2)....O(8)	-1.5	3.26	sp^3(Donor)	sp^2(Acceptor)
	Arg 112(NH1)....O(8)	-1.5	3.52	sp^2(Donor)	sp^2(Acceptor)
PRO3	Lys 32(N)....N(9)	-2.5	2.68	sp^2(Donor)	sp^2(Acceptor)
PRO6	Lys 32(N)....N(8)	-2.5	3.03	sp^2(Donor)	sp^2(Acceptor)
Aldara	Lys 32(N)....N(8)	-1.9	2.96	sp^2(Donor)	sp^2(Acceptor)
PRO2	Lys 32(N)....N(7)	-2.1	2.67	sp^2(Donor)	sp^2(Acceptor)
PRO5	Pro 55(N)....H(14)	-2.03	2.22	sp^2(Acceptor)	sp^3(Donor)
PRO4	Lys 32(N)....N(7)	-2.5	2.73	sp^2(Donor)	sp^2(Acceptor)
PRO1	Lys 32(N)....N(6)	-2.4	2.66	sp^2(Donor)	sp^2(Acceptor)
PRO9	Lys 32(N)....N(6)	-2.5	2.74	sp^2(Donor)	sp^2(Acceptor)
PRO8	Lys 32(N)....N(4)	-2.13	2.61	sp^2(Donor)	sp^2(Acceptor)

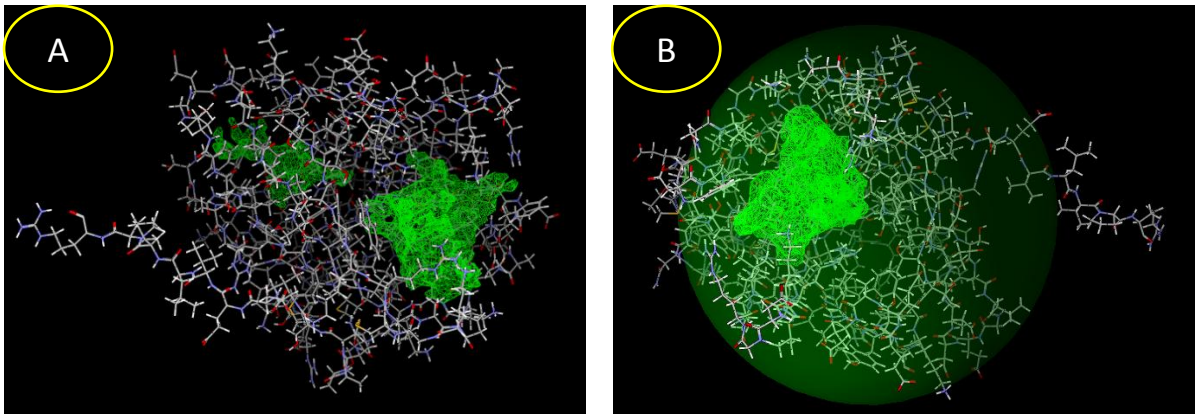
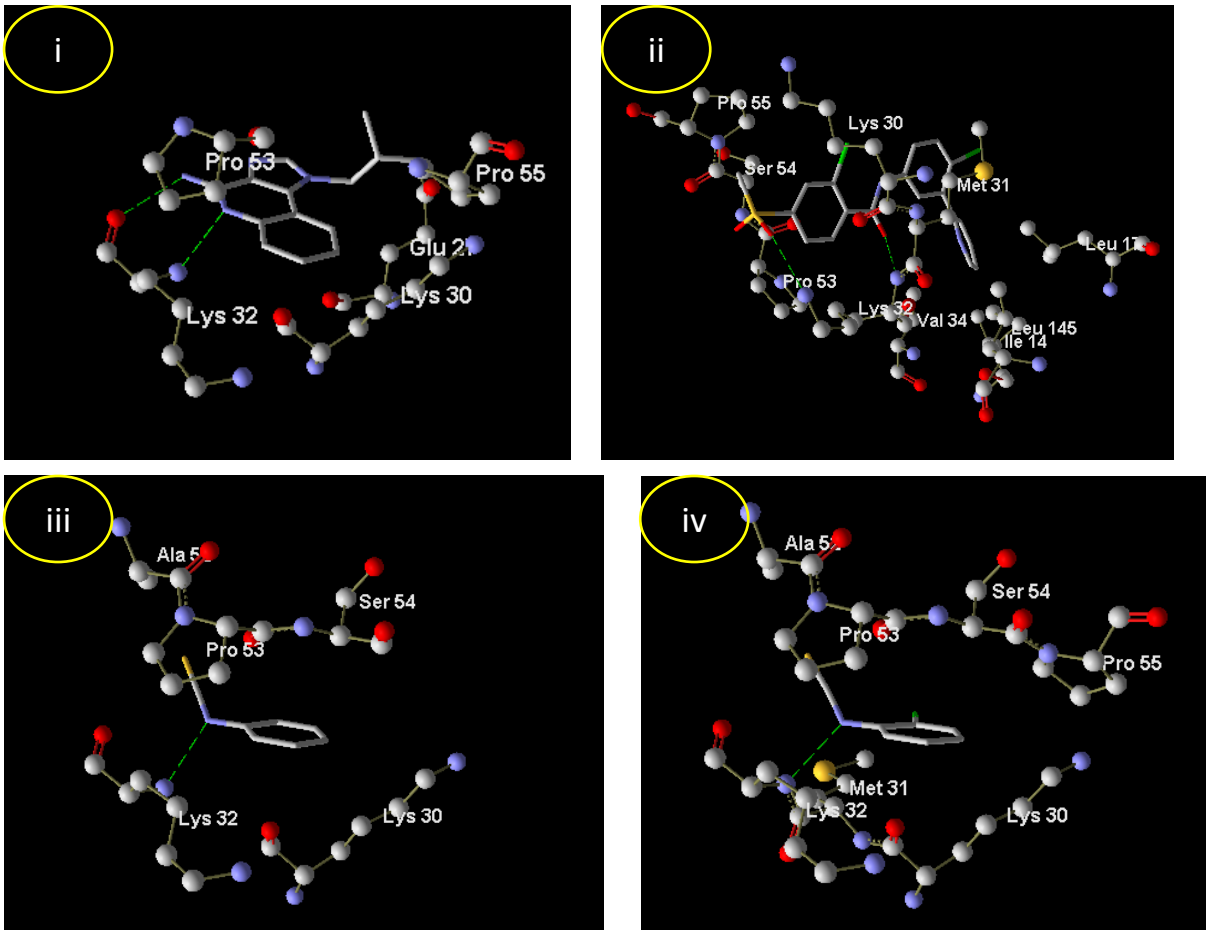


Figure 7: A: predicted cavities of 3sao (green); B: selected cavity (green sphere)for molecular docking studies.



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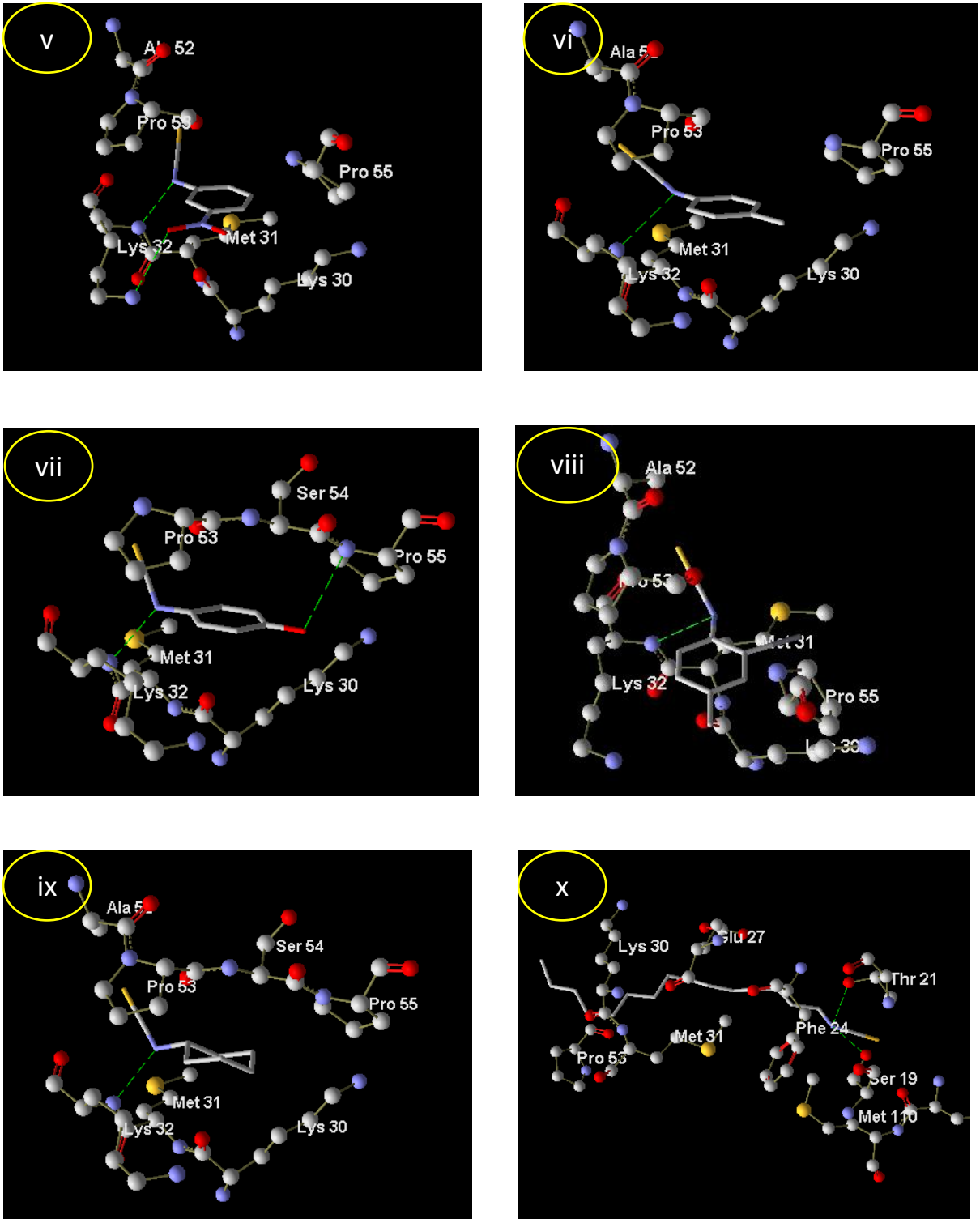

Fig 8: Molecular interaction of (i) Aldara, (ii)Erivedge, (iii)PRO1, (iv)PRO2, (v) PRO3, (vi)PRO4, (vii) PRO5, (viii) PRO6, (ix) PRO9, (x) PRO10; at the active site of 3sao

Conclusion

The *in silico* studies predicted that the isothiocyanate molecules can be an orally active drug with relatable and favourable ADMET properties. From the interaction studies, it revealed that Isothiocyanate molecules understudy interacts positively with protein targets of oral and skin cancer. Therefore, the positive interaction of ITCs with the therapeutic targets makes them a potential candidate that may result in the

inhibition of cancer progression. Amongst the ITCs understudy, Tetradodecyl Isothiocyanate (PRO 10) showed the most promising result. The results of this study give room for designing new anticancer compounds with better inhibitory activity against oral and skin cancer.

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Conflict of interest

The authors declares no conflict of interest.

References

Berry, M., Fielding, B. and Gamieldien, J. (2015). Practical Considerations in Virtual Screening and Molecular Docking. *Emerging Trends in Computational Biology, Bioinformatics, and Systems Biology*. 487-502.

Bianchini, F. and Vainio, H. (2012). Isothiocyanates in Cancer Prevention. *Drug Metab. Rev.* **36(3-4)**: 655-667.

Correnti, C., Clifton, M. C., Abergel, R. J., Allred, B., Hoette, T. M., Ruiz, M., Cancedda, R., Raymond, K. N., Descalzi, F. and Strong, R. K. (2011). Galline Ex-FABP is an Antibacterial Siderocalin and a Lysophosphatidic Acid Sensor Functioning through Dual Ligand Specificities. *Structure*. **19(12)**: 1796–1806.

Doss, C. G. P. and Kumar, T. D. (2014). Computational Approaches and Resources in Single Amino Acid Substitutions Analysis Toward Clinical Research. *Adv Protein Chem Struct Biol*. **94**: 365-423.

Du, Y., Shi, W. W., He, Y. X., Yang, Y. H., Zhou, C. Z. and Chen, Y. (2011). Structures of the substrate-binding protein provide insights into the multiple compatible solute binding specificities of the Bacillus subtilis ABC transporter Opuc *Biochem J*. **436(2)**: 283-289.

Feixiong, C., Weihua, L., Yadi, Z., Jie, S., Zengrui, W., Guixia, L. (2012). admetSAR: A Comprehensive Source and Free Tool for Assessment of Chemical ADMET Properties *J. Chem. Inf. Model.* **52(11)**: 3099–105.

Higdon, J. V., Delage, B., Williams, D. E. and Dashwood, R. H. (2007). Cruciferous vegetables and human cancer risk: epidemiologic evidence and mechanistic basis. *Pharmacol. Res*. **55**: 224- 236.

Huang, S. H., Hsu, M. H., Hsu, S. C., Yang, J. S., Huang, W. W., Huang, A. C., Hsiao, Y. P., Yu, C. C. and Chung, J. G. (2014). Phenethyl isothiocyanate triggers apoptosis in human malignant melanoma A375.S2 cells through reactive oxygen species and the mitochondria-dependent pathways. *Human and Experimental Toxicology*. **33(3)**: 270–283.

Kala, C., Ali, S. S., Ahmad, N., Gilani, S. J. and Khan, N. A. (2018). Isothiocyanates: a Review. *Res. J. Pharmacognosy*. **5(2)**: 71-89.

Kusumaningrum, S., Budianto, E., Kosela, S. *et al.* (2014). The molecular docking of 1,4-naphthoquinone derivatives as inhibitors of Polo-like kinase 1 using Molegro Virtual Docker. *J. App. Phar. Sci*. **4(11)**: 047-053.

Leach, A. R. (1994). Ligand docking to proteins with discrete sidechain flexibility. *J Mol Biol*. **235**: 345-56.

Lee, J. W. and Cho, M. K. (2008). Phenethyl isothiocyanate induced apoptosis via down regulation of Bcl-2/XIAP and triggering of the mitochondrial pathway in MCF-7 cells. *Arch Pharm Res*. **31**:1604.

Lipinski, C. A. (2004). Lead- and drug-like compounds: the rule-of-five revolution**.** *Drug Discov. Today Technol.***1(4)**:337-41.

Mitsiogianni, M., Koutsidis, G., Mavroudis, N., Trafalis, D. T., Botaitis, S., Franco, R., Zoumpourlis V, Amery T, Galanis A, Pappa, A. and Panayiotidis, M. I. (2019). The Role of Isothiocyanates as Cancer Chemo-Preventive, ChemoTherapeutic and Anti-Melanoma Agents. *Antioxidants*. **8**: 106.

Newman, D. J., Cragg, G. M. (2012). Natural products as sources of new drugs over the 30 years from 1981 to 2010. *Journal of Natural Products*. **75**: 311–335.

Pathak, D., Chadha, N. and Silakari, O. (2016). *J Mol Graph. Model*. **70**: 85-93.

Sanghani, H. V., Ganatra, S. H. and Pande, R. (2012). Molecular – Docking Studies of Potent Anticancer Agent. *J Comput Sci Syst Biol***. 5**: 012-015.

Thomsen, R. and Christensen, M. H. (2006). MolDock: a new technique for high-

ISSN 2348-0637

accuracy molecular docking. *J. Med. Chem*. **49(11)**: 3315-21.

Trachootham, D., Zhang, H., Zhang, W., Feng, L., Du, M., Zhou, Y., *et al*. (2008). Effective elimination of fludarabine-resistant CLL cells by PEITC through a redox-mediated mechanism. *Blood*. **112**:1912–22.

Vinoda, B. M., Bodke, Y. D., Vinuth, M., Sindhe, M. A., Venkatesh, T. and Telkar, S. (2016). *Org. Chem. Curr. Res*. **5(1)**.

Yeh, Y. T., Hsu, Y. N., Huang, S. Y., Lin, J. S., Chen, Z. F., Chow. N. H., Su, S. H., Shyu, H. W., Lin, C. C., Huang, W. T., Yeh, H., Yu-chiachih, Huang, Y. H. and Su, S. J. (2016). Benzyl isothiocyanate promotes apoptosis of oral cancer cells via an acute redox stress-mediated DNA damage response. *Food Chem Toxicol*. **97**: 336-345.

Zuehlke, A. and Johnson, J. L. (2010). Hsp90 and co-chaperones twist the functions of diverse client proteins. *Biopolymers*. **93(3)**: 211–217.

APPLICATION OF ELECTRICAL RESISTIVITY METHOD TO DECIPHER THE EXISTING SUBSURFACE STRATIFICATION: A CASE STUDY

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Abstract: A geophysical survey using electrical resistivity method was conducted to unravel the existing subsurface condition and ascertain the cause leading to instability of the study area. In order to obtain the objectives of the study, Vertical Electrical Soundings (VES) method was employed and the data was analyzed and interpreted quantitatively using the conventional curve matching and computer iteration method. Sounding curves of the type A and K showed three subsurface geo-electric layers, indicating weathered/fractured bedrock with thinly spread topsoil. Presence of weak zone at a shallow depth of 2m from the surface was also observed from the pseudo cross section. This study brings relevance of electrical resistivity method to give information about the variation of resistivity with depth that helps in an efficient evaluation of land instability studies.

Keywords: Electrical resistivity, Vertical Electrical Sounding, subsurface, Schlumberger configuration

Introduction

Electrical resistivity (ER) technique is one such geophysical method that has been used widely and successfully for reconnaissance survey over the years especially to ascertain the existing subsurface conditions (Plummer *et. al*., 1966; Bogoslovsky *et. al*., 1977; Mc. Cain and Foster, 1990; Denis *et. al.*, 2007; Jongmans et. al., 2007; SenthilKumar et. al., 2018; Falae *et. al.*, 2019) and to investigate the potential zones for groundwater delineation by many researchers (Kikon, 2001; Brijesh *et. al.*, 2014; Kana et. al., 2015; Hassan *et. al.*, 2017; Manimegalai *et. al.*, 2017; Umar *et. al*., 2019). The interpretation of ER data are becoming better alternatives to obtain information about the subsurface materials in land instability areas (Rezaei et. al., 2018; Bellanova et. al., 2018) and are also associated with applications in hydro geology, exploration of natural resources, geotechnical investigations, engineering geophysics, environmental surveys (Soupios et. al., 2007; Giocoli et. al., 2015; KAN, 2019). Even though the application of ER method offer some very useful information about the subsurface, it must however not be considered as a substitute for boring wells and direct testing methods for quantifying the results. It can rather be used as a complement with the conventional geotechnical methods in assessing the subsurface characterization of the instability areas (KAN, 2019).

Objective of the study

To determine the subsurface strata and its geoelectric parameters of the study area and ascertain the causes that contributes to instability of the area.

Study area

The study area is located at the construction site of the ongoing Nagaland Medical College, Kohima which is incorporated in the Survey of India topographic sheet number 83K/2 and lies between 25°41'31" and 25°41'52" North latitudes and 94°07'15" and 94°07'50"East longitudes (Fig.1).

Geological observations of the study area

The area is represented by Disang group of rocks that predominantly consists of thick monotonous black to fawn coloured shales and have undergone various stages of weathering. The exposed rocks are highly

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jointed and fractured which allows water percolation to take place into the subsurface, thus making the area more prone to instability.

Fig. 1: Location map of the study area (Prepared by Dept. of Geology, NU)

Theory

Electrical resistivity method

The fundamental theory behind resistivity method goes back to as far as 1947 by Maillet, where adequate formulation was also covered by Keller and Frischknecht (1966), Bhattacharya and Partra (1968) etc. Maxwell's equation as expressed by Feynman et. al., (1965) for materials having electric and magnetic properties is given by:

$$\nabla \times \vec{H} = J + {}^{\partial D}/_{\partial t} \quad 1$$

$$\nabla \times E = -\ {}^{\partial B}/_{\partial t} \quad 2$$

$$\nabla . \vec{B} = 0 \quad 3$$

$$\nabla . \vec{D} = Q \quad 4$$

Where H = magnetic field = $\frac{B - \mu_{\circ} M}{\mu_{\circ}}$,

B = magnetic flux density,

t = time,

μ_0 = permeability of free space,

$\vec{M}$ = magnetization,

$\vec{J}$ = current density,

Q = electric charge density,

$\vec{D}$ = electric displacement = ε_0 E+$\vec{P}$, where ε_0 = permittivity of free space,

$\vec{E}$ = electric field strength,

$\vec{P}$ = polarization.

Equation of continuity is obtained by taking the divergence of equation (1), i.e.,

$$\nabla . J - \nabla\ {}^{\partial D}/_{\partial t} = 0$$

Therefore, we have;

$$\nabla . J = -\ {}^{\partial}/_{\partial t} \nabla D \quad 5$$

Substituting equation (4) in equation (5) we get;

$$\nabla . \vec{J} = -\ {}^{\partial}/_{\partial t} \mathrm{Q} \quad 6$$

Since in the resistivity method, the electric field is generated by the direct current, hence it operates in the absence of the induction field.

For source free regions of the earth, equation (2) and (6) becomes;

$$\nabla \times \vec{E} = 0 \quad 7$$

$$\nabla . \vec{J} = 0 \quad 8$$

The electric field strength E can also be expressed in terms of the gradient of a scalar potential (V) given by;

$$\vec{E} = -\nabla V \quad 9$$

However, the relationship between E and J, as provided by Ohm's law states that the current density is proportional to the electric field strength given by;

$$J = \sigma E \quad 10$$

Where the proportionality constant, σ is called conductivity of the medium.

For an anisotropic medium, the conductivity is a second rank tensor. Thus equation (10) becomes;

$\vec{J} = \sigma_\eta \vec{E}$

Or,

$$\begin{bmatrix} J_x \\ J_y \\ J_z \end{bmatrix} = \begin{bmatrix} \sigma_{xx} & \sigma_{xy} & \sigma_{xz} \\ \sigma_{yx} & \sigma_{yy} & \sigma_{yz} \\ \sigma_{zx} & \sigma_{zy} & \sigma_{zz} \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix} \quad 11$$

Combining equations (8), (9) and (10) gives a differential equation of the type;

$\nabla (\sigma_\eta \nabla V) = 0$ 12

This is the basis of all the resistivity prospecting with direct current.

For an isotropic case, equation (11) reduces to the general Laplace's equation;

$\nabla^2 V = 0$ 13

By choosing the appropriate boundary conditions and co-ordinate system to match the geometry of a particular model of the earth, solutions to equations (11) and (12) can thus be obtained.

Materials and Methodology

The study utilized the Vertical electrical sounding (VES) method, which is a geophysical method and is based on estimation of the electrical conductivity or resistivity of the medium. In this type of resistivity sounding, by keeping the centre of the electrode system fixed, measurements are taken at different locations for various values of current electrode separations starting from small initial values to several meters. Thus variation in the electrical characteristics with depth is obtained from the apparent resistivity variation with the current electrode spacing. One of the configurations used mostly for VES is the Schlumberger configuration (Fig. 2), which has also been used for our present analysis. A resistivity meter, Aquameter CRM 500 was used for data collection and the resistivity values obtained is quantitatively interpreted (Orellana et. al., 1966; Koefoed et. al., 1979) and analyzed using the software package IPI2win (Vender Velpen B.P.A, 1998). Here, four electrodes are used, two outer electrodes for the current (source) electrode and the other two inner electrodes for the potential (receiver) electrode. The current (I) is introduced between one pair of the current electrodes, say, A and B and the potential difference (δV) produced as a result of the current flow is measured with the help of the other pair of electrodes which is the potential electrodes, say, M and N. All the four electrodes should be in a line, with the outer electrode spacing kept large as compared to the inner electrode spacing. The apparent resistivity (ρ_a) for this configuration is computed by using the formula (Telford et. al., 1990):

$\rho_a = K \frac{\delta V}{I}$, where $K = \frac{\pi}{2} [(L/I)^2 - 1]$ is the geometrical spacing factor.

In MKS system, the unit of resistivity is Ohm-meter and its conductivity, denoted by σ, which is the reciprocal of resistivity, is mho/meter.

If ρ1, ρ2 and ρ3 are the resistivity of the subsurface layers with ρ1 at the top followed by ρ2 and ρ3, then the four basic categories for classification of sounding curves, depending on the resistivity values with depth are:

ρ1 < ρ2 < ρ3: A-type
ρ1 < ρ2 > ρ3: K-type
ρ1 > ρ2 < ρ3: H-type
ρ1 > ρ2 > ρ3: Q-type

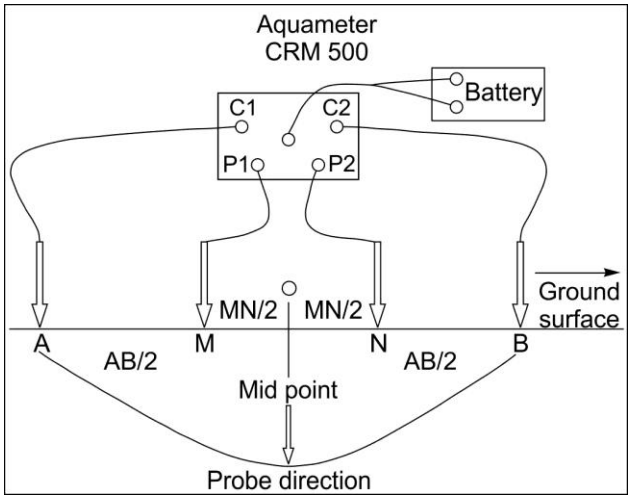

Fig. 2: Schematic diagram for the Schlumberger array field method

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Results and discussions

Resistivity analysis for the data collected at the two VES stations of the study area gave the layer model interpretations in terms of its field curves (Fig. 3) and geoelectric layer parameters (Table 1) (Loke and Barker, 1996). Curve types A and K showing three geoelectric layers were obtained from the analyzed data. Presence of curve type A with resistivity $\rho1 < \rho2 < \rho3$ suggest that the subsurface layer formation has increasing resistive nature continuously with depth and can be interpreted as the lower layers with fractured bedrock. Curves of the type K with resistivity $\rho1 < \rho2 > \rho3$ indicates that the intermediate layer has higher resistivity as compared to the overlying and underlying strata and suggest an area with lower saturated bedrock which are highly weathered/fractured (Singh *et. al.*, 2006; Gopinath *et. al.*, 2015; Gouet *et. al*., 2020).

The top soil for both the VES with resistivity value ranging between 129-651 Ω-m was observed to have thickness between 1-2 m. Each curve type obtained defines a geological bedding model of the surveyed area.

The pseudo cross section and resistivity cross section plotted with the two VES stations (Fig. 4) shows a low resistivity zone at VES 2 at a depth of 10 m below ground level. This indicates areas with good potential for groundwater. A layer of high resistivity (> 200 Ω-m) at VES 1 at a depth below 5m is observed, which are indicative of weathered or fractured zones (Alile *et. al.*, 2008; Sultan and Santos, 2008; Bairu *et. al.*, 2013; Ganesh *et. al.*, 2017). Possibility of the presence of weak zone between the two VES stations which spreads from 2 m below the ground level to a greater depth is also observed from the plot (Fig. 4).

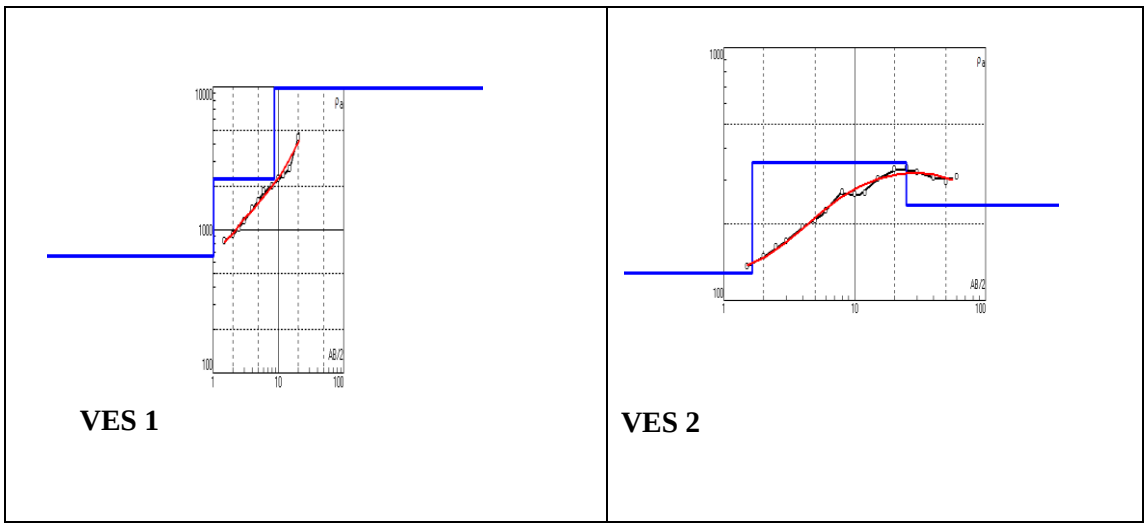

Fig. 3: VES field curves

Table1: Layer parameters for the VES points

VES No.	ρ1	ρ2 (Ω-m)	ρ3	h1	h2 (m)	h3	d1	d2 (m)	d3	Curve type
VES 1	651	2276	34000	1.02	7.73	-	1.02	8.75	-	A
VES 2	129	351	239	1.65	23.1	-	1.65	24.8	-	K

VES-vertical electrical sounding: ρ-layer resistivity: h–layer thickness: d–layer depth:
Ω-m-ohm meter: m – meter

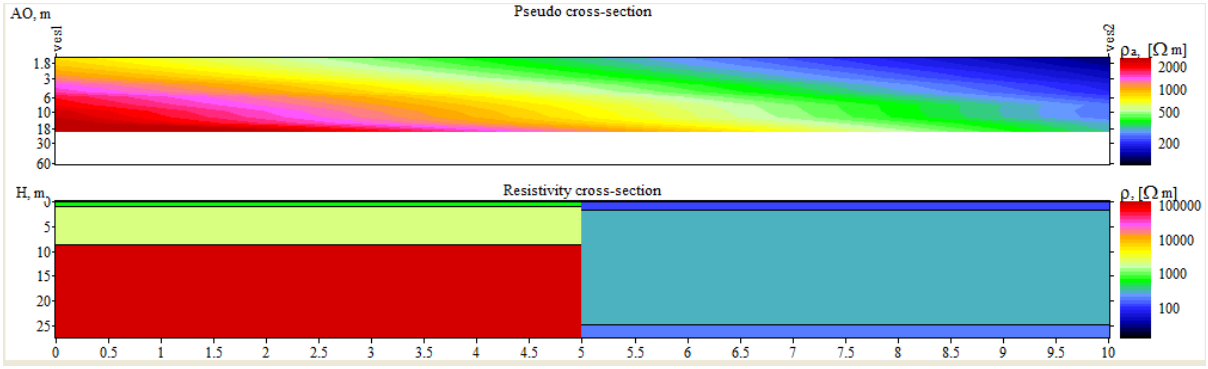

Fig. 4: Pseudo and Resistivity cross sections for VES 1 and VES 2

Conclusion

The above study provided quantitative information about understanding the existing conditions of the soils and rocks. Results of the investigation carried out at the two VES locations were interpreted and presented as typology of sounding curves, lithological layers, pseudo cross sections and resistivity cross sections. Sounding curves obtained are of A and K types, showing three geologic layers with variation of the resistivity with depth depending on the subsurface conditions. This type of curves also indicates that the area has weathered/fractured bedrock with thin top soil layer. The weathered/fractured rocks, which are predominantly shales for the study area, tend to swell on saturation, thus reducing the shearing strength of the slope material. Presence of weak zone observed between the two VES stations is also another condition contributing to the increase in weathering of the rocks present at the subsurface region. These are some factors which might have eventually triggered the occurrence of instability at the study area. However, the results obtained from electrical resistivity method needs to be co-related with the borehole data for the subsurface characterization, which still remains to be investigated.

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References

Alile, O. M, Amadasun, C. V. O. and Evbuomwan, A. I. (2008). Application of vertical electrical sounding method to decipher the existing subsurface stratification and groundwater occurrence status in a location in Edo north of Nigeria. *International Journal of Physical Sciences*. **3(10)**: 245-249.

Bairu, A, Yirgale, G. and her, Gebrehiwot. (2013). Application of vertical electrical sounding and horizontal profiling methods to decipher the existing

ISSN 2348-0637

subsurface in river Segan dam site, Tigray, Northern Ethiopia. *Journal of Environment and Earth Science*, **3(10)**: 2224-3216.

Bellanova, J, Giuseppe, G, Giocoli, A, Luongo, R, Perron, A, Lapenna, V, Piscitelli, S. (2018). Electrical resistivity tomography surveys for the geoelectric characterization of the Montaguto landslide (southern Italy). *Eng Geology*, **234**: 272-281.

Bhattacharya, P. K. and Patra, H. P. Direct current geoelectric sounding. Elseviert, Amsterdam, 135.

Bogoslovsky, V. A. and Ogilvy, A. A. (1977). Geophysical methods for the investigation of landslides. *Geophysics*. **42(3)**: 562-571.

Brijesh, V. K. and Balasubramanian, A. (2014). Hydrogeological studies and groundwater modelling, Bharathapuzha basin, Kerala, India. Scholar's Press, Germany, ISBN: 978-3-639-71113-4. 129-154.

Denis, J. and Stephane, G. (2007). Geophysical investigation of landslides. A review. *Bulletin Societe Geeologique de France*. **178(2)**: 101-112.

Falae, P. O., Kanungo, D. P., Chauhan, P. K. S. and Dash, R. K. (2019). Electrical resistivity tomography (ERT) based subsurface characterisation of Pakhi Landslide, Garhwal Himalayas, India. *Environmental Earth Sciences*. **78**: 430.

Feynman, R. P., Leighton, R. H. and Sands, M. (1965). The Feynman lectures on Physics. Addison Westley reading (3 volumes).

Ganesh, R., Gowtham, B., Manive, T., Senthilkumar, S. and Sundrajan, M. (2017). Application of Resistivity methods in landslide investigations along Mettupalayam to Coonoor highway, NilgirisDistrict, Tamilnadu, India. *Scholars Journal of Engineering and Technology*. **5(11)**: 661-667.

Giocoli, A., Stabile, T., Adurno, I., Perrone, A., Gallipoli, M., Gueguen, S., Norelli, E. and Pistitelli, S. (2015). Geological and geophysical characterization of the South-Eastern side of the high Agri valley (Southern Apennines Italy). *Nat Hazards Earth Syst. Sci* **15**:315-323.

Gopinath. V. S. T, Vinodh. K, Gowtham. B, Arulprakasam. V. (2015). Geolectrical characterization of substrata by using Geoelectrical Imaging Technique in Gagilam river sub basin, Tamilnadu, India. *International Journal of Scientific Engineering and Applied Science (IJSEAS)*, **1(6):** 451-457.

Gouet, D. H., Meying, A., Nkoungou, H. L. E., Assembe, S. P., Nouck, P. N. and Mbarga, T. N. (2020). Typology of sounding curves and lithological 1D models of mineral prospecting and groundwater survey within crystalline basement rocks in the east of Cameroon (Central Africa) using electrical resistivity method and Koefoed computation method. *Int J Geophys*. **2020**: Article ID 8630406.

Hassan, E., Rai, J. K. and Anekwe, U. O. (2017). Geoelectrical survey of groundwater in some parts of Kebbi state, Nigeria, a case study of Federal Polytechnic bye-pass Birnin Kebbi and Magoro Primary health centre Fakai local Government. *Geosciences*. **7(5)**: 141-149.

Jongmans, D., Garambois, S. (2007). Geophysical investigation of landslides: a review, *Bull Soc Géol Fr*. **178(2)**: 101-112.

Kikon, E. and Ao, K. (2001). Groundwater development in Hilly Terrain: Case studies in and around Kohima, Nagaland, Directorate of Geology and Mining, Dimapur.

Kana, J. D., Djongyang, N., Dadjé, A. and Raïdandi, D. (2015). Vertical electrical soundings for subsurface layers and groundwater investigations in the Mayo Kani area in Cameroon. *International Journal of Science and Research*. **4(2)**: 396-401.

KAN, A. (2019). Relevance of electrical resistivity geophysical method in engineering site characterization in a basement complex terrain. *Global Journal of Engineering Sciences. ISSN: 2641-2039. DOI: 10.33552/GJES.2019.02.000526.*

Keller, G. V. and Frischknecht. Electrical methods in geophysical prospecting. Pergamon, oxford, 517.

Koefoed, O. (1979). Geosounding Principles, 1. Resistivity Sounding Measurements. Elsevier Scientific Publishing Comp., Amsterdam, The Netherlands, 275.

Loke, M. H. and Barker, R. D. (1996). Practical techniques for 3D resistivity surveys and data inversion. Data inversion. *Geophysical Prospecting*. **44**: 499 - 523.

Maillet, R. (1947). The fundamental equations of electrical prospecting. *Geophysics*. **12(4)**: 529-556.

Manimegalai, M. K., Gowtham, B. and Vinodh, K. (2017). Investigation of subsurface and groundwater state at Gadilam river sub -basin, Tamil Nadu, India. *Int. J. Modn. Res. Revs*. **5(10)**: 1632-1638.

McCain, D. M. and Foster, A. (1990). Reconnaissance geophysical methods in landslide investigations. *Engineering Geology*. **29(1)**: 59-78.

Orellana, E., Mooney, H. M. (1966). Master tables and curves for vertical electrical sounding over layered structures. *Inteciencis, Madrib*. 34.

Plummer, C. C. D., Mc Geory and Carlson, D. H. (1966). Physical Geology. 8th Edition McGraw Hill Co. Inc., New York. 48-56.

Rezaei, S., Shooshpasha, I., Rezaei, H. (2018). Empirical correlation between geotechnical and geophysical parameters in a landslide zone (case study: nargeschal Landslide). *Earth Sci Res J*. **22(3):** 195-204.

Senthilkumar, V., Chandrasekaran, S. S. and Maji, V. B. (2018). Rainfall – induced landslides: Case study of the Marappalam landslide, Nilgiris district, Tamil Nadu, India. *Int J Geomech*. **18(9)**.

Singh, K. K. K., Singh, A. K., Singh, K. B., and Sinha, A. (2006). 2D resistivity imaging survey for siting water-supply tube well in metamorphic terrains: A case study of CMRI campus, Dhanbad, India. *The leading Edge*. **25**: 1458-1460.

Soupios, P. M., Georgakopoulos, P., Papadopoulos, N., Saltas, V., Andreadakis, A. et. al. (2007). Use of engineering geophysics to investigate a site for a building foundation. *J Geophysics Eng.* **4**: 94-103.

Sultan, A. S. and Santos, F. A. M. (2008). 1 D and 3 D resistivity inversions for geotechnical investigation. *J Geophys Eng*. **5**: 1-11.

Telford. W. M., Geldart, L. P.and Sherrif, R. E. (1990). *Applied Geophysics* (2nd edn. Cambridge University Press).

Umar, D. U. and Igwe, O. (2019). Geo - electric method applied to groundwater protection of a granular sandstone aquifer. *Applied Water Science*. 9-112.

Vender Velpen, B. P. A. (1998). A computer processing package for DC Resistivity interpretation for IBM compatibles. *ITC J*. **4**: 1-4.

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