https://doi.org/10.26682/ajuod.2022.25.2.10
Journal of University of Duhok., Vol. 25, No.2 (Agri. and Vet. Sciences), Pp 108-115, 2022

CATEGORIZATION OF DEBRIS FLOW AND ITS PREDICTION ALONG THE HIGHWAY ROADSIDE OF DUHOK- SHEKHAN

HIVEEN MEQDAD AHMAD
Dept. of Soil and Water Sciences, College of Agricultural Engineering, University of Duhok, Kurdistan Region

(Received: June 7, 2022; Accepted for Publication: October 18, 2022)

ABSTRACT

Debris flow is caused by various triggers including intensive rainfall, snowmelt, and earthquakes. Quantifying the number, area, and volume of debris is critical to determine debris volume and its risks. Soil physical analysis in conjunction with laboratory geotechnical soil properties of some selected site along the highway roadsides of Duhok-Shekhan assisted in developing empirical models to predict debris flows volume from some input parameters like area, vegetation cover percent, and, the site slope. The debris flow volume was based on measuring (the length, width, and depth) of the individual debris flow sites. The results indicated that debris flows were significantly correlated with debris flow area. In contrast, it was poorly correlated with each of the vegetation cover percentages and site slope; Furthermore, it was shown that the debris flow can be predicted with reasonable accuracy at this stage of study by an exponential model based on debris flow area only. This will enable the responsible agents to take measures to mitigate the risk of a debris flow along the highway roadsides in the study area.

***KEYWORDS*:** Debris flow, classification, Volume, coefficient, plastic index.

INTRODUCTION

Debris flows are natural phenomena in which water-laden masses of soil and fragmented rock rush down mountainsides, toward stream channels, entrain objects in their paths, and form thick, muddy deposits on valley floors (Morton et al.,2003). The largest prehistoric flows have had volumes exceeding 1 billion cubic meters. (Kean et al.,2019) they found that debris flows can be more frequent and pose a significant hazard in many steep, mountainous areas, and have received particular attention in Japan, China, and Taiwan. The velocity of debris flow is an important factor in the design of mitigation structures (Johnson, 1984) When analyzing the hazard potential of long run-out occurrence, the interactions between volume, area, and travel distance are very important (Legros, 2002). Both (Bottino et al., 2002); Schneider et al., 2011a) shows that empirical correlations and numerical models suggest that the travel distance of rock avalanches over ice exceeds that of rock avalanches traveling over other substrates. (Evans & Clague, 1999) illustrated that several mechanisms exist to explain these observations, including the surface friction of ice is lower than that of rock or soil and on the other hand melting of entrained snow and ice increases the fluidity of debris. Research involving both empirical relationships and numerical models has identified volume, topography, and flow (Pudasaini & Krautblatter, 2014; Schneider et al., 2011). However, (Park et al., 2017) show that high-magnitude storms cause frequent debris flows triggered by heavy rainfall during the summer monsoon rainy season in Korea. Debris is caused by various triggers including intensive rainfall, snowmelt, and earthquakes (Guzzetti et al., 2009), whereas quantifying the number, area, and volume of debris is critical to determining debris susceptibility and hazard (Guzzetti et al., 1999). (Cruden,1991) and (Varnes, 1978) has been utilized as the foundation for debris flow categorization by many writers, their categorization was based on five forms of movement: fall, topple, slide, spread, and flow. Moreover, three different types of materials are involved in the movement: rock, debris, and soil as explained by (Hunger et al.,2014). Classification with semi-automated object-oriented methods in optical imagery allows for debris flow mapping to be cleared (Martha et al., 2010). Recently remote sensing

hiveen.meqdad@uod.ac

techniques have become widely used for the detection and mapping of the position, size, and shape of debris flow (Cardenal et al., 2001; Guzzetti et al., 2012). Generally, the causes of debris flow were explained according to (Chen et al., 2011), which showed several categorized causes firstly, Morphological causes secondly, Human activity causes finally, Geological causes including weathered materials and erosion. (Schwarz et al., 2010) refer to some worldwide examples of debris flow around the world logging on frequency and distribution of debris in three different watersheds on Vancouver Island, British and Columbia.The objectives of the current study; 1-To find the correlation equation between the volume of debris flow material in different sites with an area of debris flow and some other affected factors such as slope gradient and vegetation cover for each site, 2- To determine the membership of the study site debris flow type according to the standard classification.

MATERIALS AND METHODS

1-Study area

Along the line connecting Duhok Governorate with the Shekhan sub-district, five study case sites were selected in which debris and soil erosion occurred due to various factors such as weather (precipitation), human activity, or other factors (ArcGIS software Map2021) Fig. (1). The study debris coordination sites were shown in table (1) and fig. (2). Rainfall-triggered debris flow was the most mutual type of the grade of debruises that occurred in hillslope and mainly on natural causes, others originated from highway roads in steep terrain. In current study sites some field works were conducted for the purpose of taking soil samples, determining the dimensions of the study debris flow such as (length - width - height) of the sites, as well as estimating the vegetation cover percentage by using (Daubenmire Cover Class Method) and the slopes and debris flow diameters were measured by using (Abney level, clinometer, and linen tape measure), table (2) and fig (3).

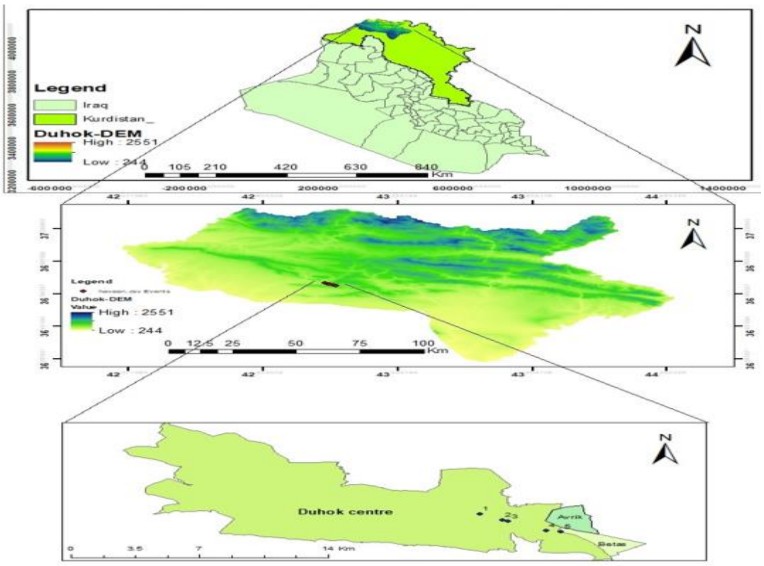

Fig. (1):- Duhok Map shows Debris flow study sites.

Table (1):- Geographic coordinates of the study debris flow sites.

Sites	Latitude	Longitude	Altitude (m)
1	36°50′28.2″	43° 04′17.6″	672
2	36° 49′26.1″	43°05′20.2″	782
3	36°49′25.7″	43° 05′27.5″	798
4	36° 49′25.4″	43° 06′22.4″	821
5	36° 49′26.6″	43° 07′03.6″	824

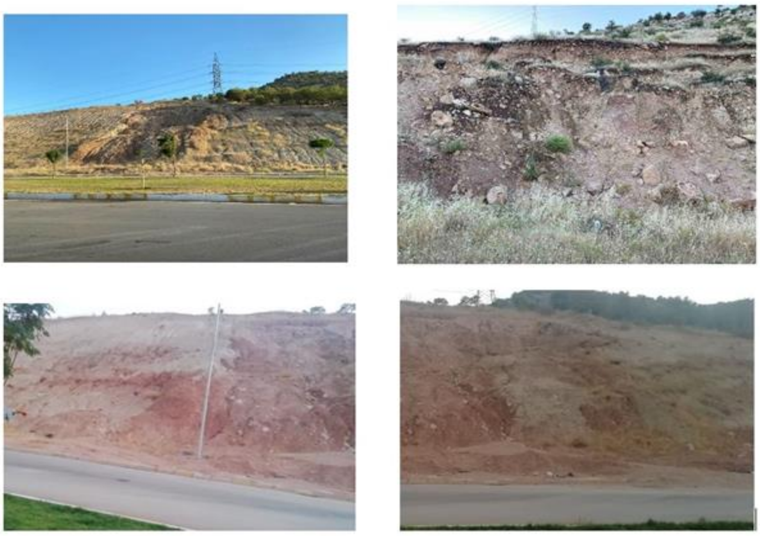

Fig.(2):- Image of study sites.

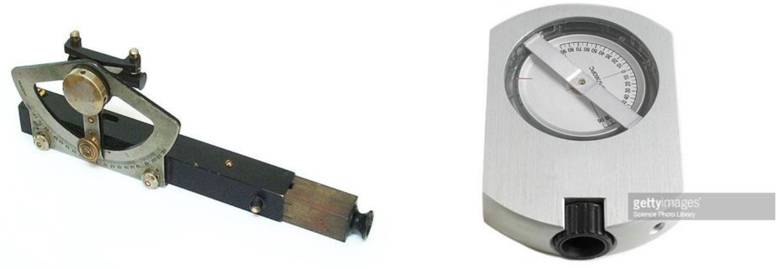

Fig. (3):- Abney level & clinometer

Table(2) :-Debris flow diameters.

Sites	Length (m)	Depth(m)	Height(m)	Area of D.F(m^2)
1	180	50	40	3600
2	160	65	80	6400
3	150	60	80	6000
4	130	15	35	2275
5	80	43	60	2400

2-Sampling preparation:

Five soil samples were collected from study debris flow sites at depths from (0-50cm) which were dug by auger tool, three randomized digs surrounding each debris flow were taken, and five composite samples were prepared, air-dried, ground, and sieved to pass through a 2-mm sieve and kept in plastic bags until use.

3-Soil Analysis:

Some soil physical analyses in the laboratory of Agriculture college that related to the current study were done such as soil particle size distribution (Black, 1965), saturated moisture content calculated depending on field capacity, and wilting point moisture contented, table (3). Both liquid limit and plastic limits were determined according to ASTM D432,424 (1986). In situ saturated hydraulic conductivity was measured by inverse auger hole method as described by (Potree and ch,1962) table (3) and revised by (Al-Lame and Al Janaby,1992), also, the soil bulk density was measured in the field using the core method as outlined by (Blake and Hartage,1984).

Table (3):-Some selected characteristics of the research soils from various debris flow sites.

Site	Particle size Distribution %			Texture class	Bulk density (kg/m^3)	Ks mm/hr.	WP%	FC %
	Sand	Silt	Clay					
1	7.71	36.47	55.80	Clay	1940	2.49	0.33	0.48
2	13.26	36.64	50.10	clay	1220	2.73	0.29	0.44
3	14.52	35.21	50.27	Clay	1220	2.20	0.29	0.44
4	18.80	36.80	44.40	clay	1500	3.00	0.25	0.40
5	21.33	33.94	44.73	Clay	1250	2.15	0.25	0.40

4-STATISTICAL ANALYSIS

Correlation equations were determined between debris flow and all other three factors (Area, Slope gradient vegetative cover of study sites), to show how the mentioned factors affect debris flow material currency and then reasonably contribute of increase the debris material events, fig (4, 5, 6)

RESULTS AND DISCUSSION

1-Debris Flow Type and Classification:

There have been several classifications of debris provided, but the classification released by Varnes in 1978 has been utilized as the foundation for debris flow categorization by many writers. The debris flows that were presented in this study case were classified into three main types, according to the classification mentioned in the literature, by Varnes in 1978 which has been utilized as the foundation for debris flow categorization. Debris flow site (1) is geologically caused by weak or sensitive materials, whereas debris flow for sites (2,3,4) are typical rapid mass movement in which a combination of loose soil, rock, and organic matter, Finally, debris flow site (5) is categorized under human activity caused by the excavation of slope or its tops. A mathematical measure was used to determine the debris flow volume by recently deteriorated foothills along highway roads at the study sites. Individual debris-flow volumes in the study area vary greatly, as seen in (Figure 1. & Table 1) The smallest debris flow volume was approximately 2061m^3, of material, while the biggest was nearly 88443 m^3. The mean volume was 44212 m^3, with a standard deviation of 36261 m^3 (Table 2). Thus, the 5 debris flows in the current study area theoretically produced about 44212 m^3 of intermingled material; consisting of rocks, soil, and mudflow. The debris flows images for which informed were plotted in (Figure 4) The statistical measure of R-squared (R^2) represents the proportion of the variance for a dependent variable volume of debris flow material m^3 that's explained by independent variables Area m^2, Slope gradient, and vegetation cover percent, R^2 equal (0.618, 0.38, & 0.19) respectively, R-Squared value will depend on the field context. In the current study, R-Squared 0.618 showed a moderate correlation equation between the area and the volume of debris flow materials (Figure 4), this result was in the line with that illustrated by (Larsen et al. 2010), whereas the R^2 in the (Figure .5&6) showed a low correlation as illustrated between debris flow and the vegetative cover % but it was illustrated moderate relation between debris flow materials and slope gradients R^2 equal, 0.38). However, the correlation depends on the specific analysis such as the nested effect of more than one factor on the moderate relation debris flow material. Therefore, the correlation between the vegetative cover and debris flow was positive and extrusive with R^2 equal to 0.19, this expected result is due to the fact that vegetation covers and root systems for (trees, sharp, and grass) have high effects on stabilization and prevent soil surface, in addition of that most soils texture of the study sites were shown clay texture, table (3) which has strong adhered, struggle and resistance to degraded. Finally, the slope gradient equation with debris flow volume correlated was showed correlation R^2 equal to 0.38%, this inverse correlation explains that as the slope gradient is small the debris flow material had been largely due to continuous product debris flow at each rainfall contrarily of highly sloping gradient which causes debris in once.

hiveen.meqdad@uod.ac

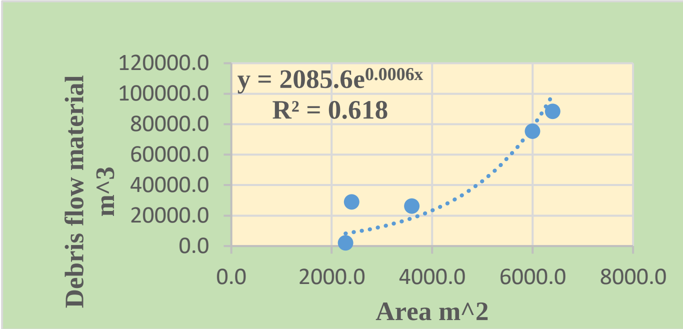

Fig. (4):- Correlation equation between the volume of (D.F) and the Area (D.F).

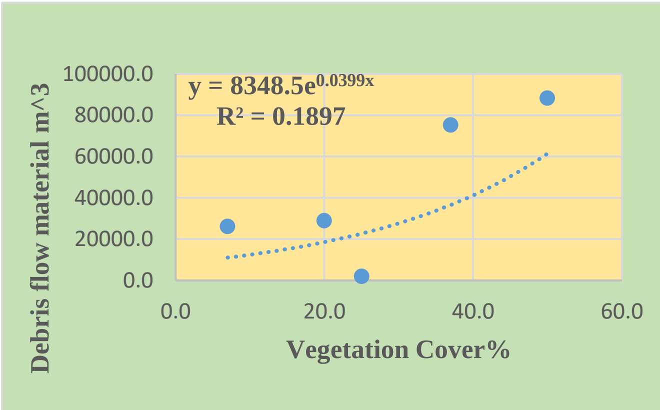

Fig. (5):- Correlation equation between the volume of (D.F) and the Slope gradient (D.F).

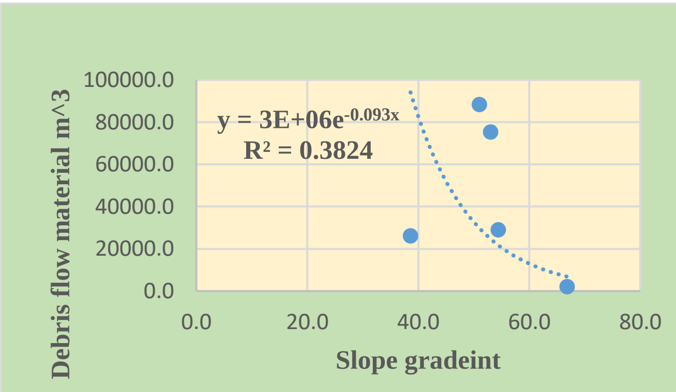

Fig.(6):-Correlation equation between the volume of (D.F) and the vegetative cover (D.F).

2-plasticity index indicators

The numerical difference between moisture-measure sites, where the minimum value was (6.9 %) at debris flow site (5) and the maximum values (14.2 %) at the debris flow site (4), the Plasticity Index flow and coefficient of determination are shown in (Table.4).The saturated hydraulic (K_s)conductivity of study soil sites ranged between 2.15 mmh^{-1}, at the debris flow site (5) and 3.00 mmh^{-1} at the debris flow site (3) whereas (K_S) in the topsoil was ranged from 3-5 mmh^{-1}. Conspicuously the correlation between the saturated hydraulic conductivity (K_s) and the plasticity index of soil samples was shown a weak relation according to linear equation:

Y=4.3378X-1.1753 with R^2 = 27%.

Where Y= hydraulic conductivity (Ks)

hiveen.meqdad@uod.ac

in mmh^{-1} X= plasticity index percentage The results indicate that both physical indicators (PI%) & (K_s mmh^{-1}.) showed significant effects on water intake and the most debris flow occurring by highly intensity rainall on a prominent slope within a single slide area (Stock et al., 1986).

Table (4) :-Correlation equation between water content and number of bowls

	Equation	R^2	Plastic limit (PL%)
1	Y= -10.55Ln(x)+68.335	0.94	9.13
2	Y= -8.021Ln(x)+64.630	0.94	7.26
3	Y= -8.378Ln(x)+69.914	0.98	11.11
4	Y= -0.3357Ln(x)+52.043	0.99	14.20
5	Y= -5.413Ln(x)+69.306	0.99	6.95

Where Y= Water content %   X=Number of blows

CONCLUSION

The most outstanding conclusion that to can be drawn from this study was the debris flow volume is closely related to the area of debris flow. Conversely and unexpectedly this parameter was poorly correlated with vegetation cover and moderately with slope gradient. The power relation model, which was based on the area of a debris flow can be used to predict the debris flow with reasonable accuracy at this stage of the study. Expanding the database may lead the researchers to further improve the accuracy of debris volume prediction.

REFERENCES

Anees, M. M., Qasim, M., & Bashir, A. (2017). Physiological and physical impact of noise pollution on environment. *Earth Science Pakistan*, *1*(1), 08-11.

Black,C.A., D.D.Evans, L.E.Ensminger, J.L.White and F.E.Clark.1965. Methods of soil analysis. part1, 2 . Agron, Mono. Am. Soc.Agron. Madison, Wisconsin.

Blake, G. R. and K. H. Hartage. (1984). Bulk density. In A. Klute (ed.) Methods of Soil Analysis,2nd ed., Agronomy Monograph no.

9. Madison, WI, American Society Agron., pp. 363–375.

Bottino, G., Chiarle, M., Joly, A., & Mortara, G. (2002). Modelling rock avalanches and their relation to permafrost degradation in glacial environments. Permafrost and Periglacial Processes,

13(4), 283–288. https://doi.org/10.1002/ppp.432

Cardenal, J., Mata, E., Delgado, J., Hernandez, M. A., and Gonzalez, A.(2001). Close range digital photogrammetry techniques applied to landslides monitoring, Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci., XXXVII, 235–240,

Chen, I. C., Hill, J. K., Ohlemüller, R., Roy, D. B., & Thomas, C. D. (2011). Rapid range shifts of species associated with high levels of climate warming. *Science*, *333*(6045), 1024-1026. Cruden, D.M and Varnes, D. (1996). Landslide types and processes. In Landslides Investigation and Mitigation; Transportation Research Board: Washington, DC, USA, pp. 36–75.

Cruden, D.M. (1991). A simple definition of a landslide. Bull. Int. Assoc. Eng. Geol., 43, 27–29.

Evans, S. G., & Clague, J. J. (1999). Rock avalanches on glaciers in the Coast and St. Elias Mountains, British Columbia. In: Proceedings of the 13th Annual Vancouver Geotechnical Society Symposium, Vancouver, (pp. 115-123).

Guthrie RH. 2002. The effects of logging on frequency and distribution of landslides in three watersheds on Vancouver Island, British Columbia. Geomorphology. 43:273–292.

Guzzetti, F., Manunta, M., Ardizzone, F., Pepe, A., Cardinali, M., Zeni, G., Reichenbach, P., and Lanari, R. (2009) Analysis of Ground Deformation Detected Using the SBAS-DInSAR Technique in Umbria, Central Italy, Pure Appl. Geophys., 166, 1425–1459,

Guzzetti, F., Mondini, A. C., Cardinali, M., Pepe, A., Cardinali, M., Zeni, G., Reichenbach, P., and Lanari, R.(2012). Landslide inventory maps: New tools for an old problem, Earth-Science Rev., 112, 42–66,

Hungr, O.; Leroueil, S.; Picarelli, L (2014).The Varnes classification of landslide types, an update. Landslides, 11, 167–194.

Iverson, R.M., 1997, The physics of debris flows, Reviews of Geophysics, 35(3): 245–

296" (PDF). Archived from the original(PDF) on 2013-06-03. Retrieved 2013-10-18.

Johnson, R. C., Schmid, G. P., Hyde, F. W., Steigerwalt, A. G., & Brenner, D. J. (1984). Borrelia burgdorferi sp. nov.: etiologic agent of Lyme disease. *International Journal of Systematic and Evolutionary Microbiology*, *34*(4), 496-497.

Kean, J.W., Staley, D.M., Lancaster, J.T., Rengers, F.K., Swanson, B.J., Coe, J.A., Hernandez,

Larsen IJ, Montgomery DR, Korup O. (2010). Landslide erosion is controlled by hillslope material. Nat Geosci. 3:247–251.

Legros, F. (2002). The mobility of long-runout landslides. Engineering Geology, 63(3–4), 301– 331. https://doi.org/10.1016/S0013-7952(01)00090-4

Martha, T. R., Kerle, N., Jetten, V., van Westen, C. J., & Kumar, K. V. (2010). Characterising spectral, spatial and morphometric properties of landslides for semi-automatic detection using object-oriented methods. *Geomorphology*, *116*(1-2), 24-36.

Morton, D.M. R.M. Alvarez, and R.H.(2003) Campbell. "PRELIMINARY SOIL-SLIP SUSCEPTIBILITY MAPS, SOUTHWESTERN CALIFORNIA" (Open-File Report OF 03-17 USGS)

Park JW, Choi BK, Cha DS. (2017). Spatial distribution and casual causes of shallow landslides in the Jinbu area of Korea. J For Environ Sci. 32 (2):130–135.

Pierson, Thomas C. (2005). Distinguishing between debris flows and floods from field evidence in small watersheds. US Department of the Interior, US Geological Survey,

Potree and ch,(1962.) revised by (Al-Lame and Al Janaby,1992), also, the soil bulk density was measured in the field using the core method as outlined by (Blake and Hartage ,1984).

Pudasaini, S. P., & Krautblatter, M. (2014). A two-phase mechanical model for rock-ice avalanches. Journal of Geophysical Research 119(10), 2272–2290.

Schneider, D., Huggel, C., Haeberli, W., & Kaitna, R. (2011a). Unraveling driving factors for large rock-ice avalanche mobility. Earth Surface Processes and Landforms 36(14), 19481966. https://doi.org/10.1002/esp.2218

Schneider, D., Kaitna, R., Dietrich, W. E., Hsu, L., Huggel, C., & McArdell, B. W. (2011b). Frictional behavior of granular gravel-ice mixtures in vertically rotating drum experiments and implications for rock-ice avalanches. Cold Regions Science and Technology, 69(1), 70– 90. https://doi.org/10.1016/j.coldregions.2011.07.001

Schwarz M, Preti F, Giadrossich F, Lehmannb P, Or D. 2010. Quantifying the role of vegetation in slope stability: a case study in Tuscany (Italy). Ecol Eng. 36:285–291.

Sigman, J.L. A.J., Allstadt, K.E. and Lindsay, D.N., 2019. Inundation, flow dynamics, and damage in the 9 January 2018 Montecito debris-flow event, California, USA: Opportunities and challenges for post-wildfire risk assessment. Geosphere, 15(4), pp.1140-1163.

Varnes, D.J. (1978). Slope Movement Types and Processes. Transportation Research Board Special Report: 11–33. In SpecialReport176: Landslides: Analysis and Control; Transportation Research Board: Washington, DC, USA.

پوخته

چونه بەرمایان دهێته وەسف کرن بهندەک پروسیسێن جوراو جور کو ژ ئەنجامێ لڤێنێن وان مادێن بەرەڤ خوار وژێههلی کەندالان درووست دبن بو نموونه بەر ، ئاخ ، مادێن ئەندامی ، یان تێکەڵ بوونا ڤان مادان،لڤینا ڤان مادان دبیت ژ ئەگەرێ کەفتن، بسەرئێکداهاتن، یان هریانان. هندەک بەرمایک هێدی دلڤن ودبنه ئەگەرێ زیانێن گاڤ ب گاڤی ، ل دەمێ هندەک گەلەک بلەز دلڤن کو دبنه ئەگەرێ ژ ناڤچوون و خرابونێن نەچاڤەرێکری ژنیشکەکێڤه یێن ساخلەتان. سێ جۆرێن لڤین دروست دبیت ژ ئەگەرێ ئاڤێ ، هەوای ، یان بەستیێ و زانستێ تەبەقاتێن ئاخێ .تاقیکرنێن فیزیائییێن جهێ ڤەکولینێ دگەل احتیمالێن جیۆتێکنیکییێن لابورا ئاخێ دهاریکاربوون دپێشڤەچوونا پێشبینییێن مۆدێلێن چوون و لڤینا بەرمایکان ، وە پیڤانێن تیرەیێن)(درێژیا چوونا بەرمایکن،فره هی،کیراتی)یێن لڤینا بەرمایکێ ، پەیوەندیێن پێکڤه گرێدانا جهێ لڤینا بەرمایکا دگەل قەبارێ بەرمایکن ل (5) جهێن لڤینا وان بو ڤەکولین بوفاکته ری بیکفهکریدانی(62%)نافبه را قهباریی و روبه ری ، لی بیکفه گریدان ناف بهرا سلوبی وهه بونا ریژ ا که سکاتیێ لکهت قبارا هریانێ (19%و42%) لیدیف ئیك وکریدانا فان فاکته را لکه ل لڤینا بەرمایکان، ریکایه که ژ بو پێشکەفتی دکاریت ب گرنگیەکا باش ڤێ ترس وریدانا هاتنا خوارا بەرمایکان کێم بکەت ل دوورێن رێیا دناڤبەرا دهوک _ شیخان دا.

hiveen.meqdad@uod.ac