Transboundary hydrology, climate change and its impact on flood factors in the Kabul-Swat floodplain of Hindu Kush region

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This study analyses the transboundary hydrology, climate change and its impact on flood factors in the Kabul-Swat floodplain, Hindu Kush region. In action 3rd, the Sendai Framework for disaster risk reduction has insisted to strengthen regional exchange on disaster risk information for better understanding of complex transboundary risks, cascading and compound disasters. It was found from the analysis that globally there is a rising trend of hydro-meteorological events both in terms of frequency and intensity and the same is attributed to changing climate scenario. The Kabul-Swat floodplain is no exception to it. During past decade (2011-2022), Pakistan has been declared amongst the top ten climate affected countries. The analysis revealed that the recurrences of flash floods, riverine floods, drought, long wet spells, intense rainfalls, heavy snowfall, late and early rainy seasons and rising trend in temperature have been identified as the major flood contributing factors and clear manifestations of climate change impacts. It was found that in the study region, the drought event (1997-2005) has paralyzed the agriculture sector and put tremendous pressure on the regional economy. It was followed by century worst flood of 2010, 2013 and 2022, and caused billions of US$ damages to critical infrastructure, agriculture and other sectors. The analysis revealed that in Afghanistan investments have been made on building new dams over the Kabul River and it has posed serious implications on the downstream communities of Afghanistan and Pakistan. In a changing climate scenario, the Indus Water Treaty is at stake, while Kabul River Treaty has yet to mature. In the study region, hydro-meteorological disasters are expanding the canvas and thereby calls for effective mechanism of forecasting, early warning, response, adaptation and mitigation to minimize the flood impacts.

Keywords: Climate Change; Transboundary Hydrology; Intense Rainfall; Flood; Agriculture

Identification of groundwater potential zones using multi influence factor approach: a study of district Mohmand, Khyber Pakhtunkhwa

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The massive usage of groundwater in municipal, agricultural, industrial, and other initiatives makes it one of the most significant natural resources. Around the world, more than 1.5 million people are dependent on groundwater to meet their daily water needs. Over the last few decades, Pakistan has drastically changed from being a water-abundant to a water-stressed country. The water crisis in Mohmand District has aggravated in last couple of years, causing several wells and water supply schemes to dry up because of the prolonged dry spell and depletion of the water table in the hilly areas. In this study, the geographic expansion of groundwater potential zones in district Mohmand was evaluated using the geospatial multi-influencing factor methodology. In the current study, effective factors were slope, drainage density, geology, rainfall, soil, land use/land cover, and lineament density. Multi-influence factor (MIF) approaches are used to calculate the weight and score of each effective parameter. Based on how well they recharge aquifers and how much groundwater is potentially present, the subclasses were assigned a weightage of (A) (Major effect) and (B) (minor effect) within each influencing parameter. Using ArcGIS 10.5, the groundwater potential zone was then defined after the thematic layers were combined with a weighted overlay tool. Our results were categorized into four zones namely poor, moderate, good, and very good potentiality. This study found that zones with very good groundwater potential covered an area of 25.78 km2 (1.20% of the total area), good zones covered an area of 161 km2 (7.53%), moderate zone covers a total area of 1088.92 km2 (50.81%), and poor zone covers an area of 866.7 km2 (40.44%). The study found that the geospatial-assisted multi-influencing factor approach is a practical and effective technique for the evaluation of groundwater potential zones and can be successfully used to improve the conceptual understanding of groundwater resources of District Mohmand, Khyber Pakhtunkhwa Pakistan.

Keywords: Multi-influencing factor; Geographic information system; Groundwater Potential zones; Weighted overlay; Arc GIS

Monsoon 2022 floods and its impacts on agriculture land using geospatial approaches: a case study of Khyber Pakhtunkhwa, Pakistan

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Pakistan is among the most vulnerable countries facing severe episodes of climate change-induced hydro-climatic extremes, including heatwaves, floods and droughts. These extreme events have significant implications on agriculture, soil health, groundwater and socioeconomic conditions. In 2022, Pakistan has experienced a biggest natural disaster in its history explained by a series of hydrometeorological anomalies. First extreme heatwave during May followed by a devastating flood disaster during August 2022. Such natural hazards have hampered national socioeconomic conditions. Floods affect the whole province of Khyber Pakhtunkhwa (KP) Pakistan; however, nine districts in the province were severely affected by the Monsoon-2022 Flood. In southern districts (especially DI Khan and Tank) were severely affected by the floods. In northern districts Swat, Dir Lower, Dir Upper and some areas of District Chitral were affected. In central parts of the province, District Nowshera, Charsadda and Peshawar were affected by the recent flood. Field data were collected and imported to geospatial format for further analysis and the damages were physically verified. The results disclosed that in DI Khan region, recent monsoon spell damaged 1377.544 km^2 crop area. While 270.146935 km^2 cropped area fully damaged or partially damaged in district Tank region. In Peshawar region, the crop lands in Charsadda were severly damaged where the sugarcane and maize crops were affected. In Charsadda, Nowshera and Peshawar 117.555 km^2, 467. 745 Km^2 and 30.081 km^2 area was damaged, respectively. In Malakand region, Swat was much affected by the current spell of Monsoon damaging 122. Km^2 area . Similarly, 63.603 km^2 area of Dir Lower , 15.147 km^2 of Dir Upper and 575.678 km^2 agricultural land of Chitral were hit by the flood 2022.

Keywords: Monsoon; GIS, RS; Disaster; Climate Change.

Application of morphometric ranking approach using geospatial techniques for flash flood susceptibility modelling in district Shangla, North Pakistan

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Every year, disaster strikes, and led to thousands of casualties and deaths around the world. A meteorological disaster such as flash floods is a multifaceted hydro-meteorological phenomenon that can cause a huge loss to human life and can create severe economic problems. In this study, techniques based on Geographic information system and Remote sensing were used to get the flood susceptibility map for District Shangla in the North Pakistan. For the susceptibility of flash floods, geo-morphometric ranking model was used. Various caisative factors were considered including; topography, river pattern and flow accumulation. ALOS PALSAR digital elevation model was used for calculating the required causative factors. Eleven different sub-basins were delineated in the shangla basin. A total of eighteen marphometric parameters were studied, these parameters included; area, stream order, stream frequency, stream number, stream length, drainage density, relif, relif ratio, circulatory ratio, gradient, elongation ratio, shape factor, compactness cofficient, rudgness number, goemetry number and length of overland flow factors. The morphometric ranking approache (MRA) score was determined with a range of 1 to 5. Rank 5 represents high risk while rank 1 exhibits low risk. The resluts of the model were categorized into five flood vulnerability classes; very low, low, moderate, high and very high. The study finds that the geomorphometric ranking model is the most applicable model in the study region. The total population of shangla district is 757,810 with a population density of 480 person per sq km^2 and 23% of the total geographic area (364.11km^2) is more valnarebale to high flash flood.

Keywords: Geo-morphometric; GIS; RS; Susceptibility; Vulnerability; Flash flood

Rainwater harvesting for agriculture development in Barani southern district Karak, Khyber Pakhtunkhwa, using geospatial technology

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Water acts as the most necessary feature in daily lives which is reducing at a higher rate in both rural and urban sectors and the reason is rapid growth in farming and household necessities. Hydrological modelling subsurface water acts as the most important feature because of shortage in better quality groundwater and larger use for household, farming and commercial utilization. This study is mainly focused on rainwater harvesting in southern District of Khyber Pakhtunkhwa District Karak. Water is the main problem of District Karak that is why the agriculture productivity is less then amount of available land for crops. The study is also focused on agriculture development by proposing different sites for rainwater harvesting using latticed technology GIS and RS. The research is based on both lab work and field work. A field survey has been arranged to verify all the results using handheld GPS; the lab work includes all the analysis done by ArcGIS software and other Geospatial software. Meanwhile allocating appropriate scoring the considered variables based on accessibility, condition of the locality has been shown in map. Final statistics of the weighted overlay is categorized into five grades including poor, low, good, high and lastly the very high grade. The analysis reveals that 95.205518 sq.km area contains very high, 877.0313 sq.km consist of high, 1286.237563 sq.km include good, 351.079124 sq.km contains poor potential to suitability according to rainwater. This work is strongly recommended to Soil and water conservation department because they have the mandate to harvest rainwater. Designers, developers and administrators can be equally benefited from processed maps to allocate Dam, conservation structures and check dam sites within national water policy.

Keywords: GIS; RS; Rainwater; Harvesting; Conservation; ArcGIS; MIF

Application of morphometric ranking approach (MRA) using geospatial techniques for flash flood susceptibility modeling in district Khyber, Pakistan

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Every year, severe and extreme meteorological disasters occur which brings an enormous amount of human and material losses all around the world. Among these meteorological disaster, flash flood which is a hydro meteorological phenomenon is of serious concern because of its deadliest nature in term of not only the number of people affected worldwide but also the fatalities it causes globally. In this study, Geographical Information System (GIS) and Remote Sensing Techniques (RS) were used to identify the susceptible zones for flash flooding in district Khyber, Pakistan. For the flash flood's susceptible zones identification, geo morphometric ranking model was used. Various casual factors were considered including; topography, river pattern and flow accumulation. ASTER digital elevation model (DEM) was used for calculating the required causative factors. Forty four different sub-basins were delineated in the Bara river and Landikotal main stream basins. A total of twenty two morphometric parameters were studied included; Sub-Basin Area (A), stream order, stream length, stream number, bifurcation ratio, basin length, basin area, basin perimeter, circularity ratio, shape factor, elongation ratio, compactness coefficient, stream frequency, drainage density, Length of overland flow, basin relief, relief ratio, ruggedness number, hypsometric integral, basin slope, drainage texture, gradient, geometric number. The morphometric ranking approache (MRA) score was determined with a range of 1 to 5. Rank 5 represents high risk for flash flooding while rank 1 exhibits low risk. The results of the morphometric ranking approach were categorized into five flood susceptibility classes; very low, low, moderate, high and very high. Due to its precise and accurate results, it proves that the geomorphometric ranking model is the most applicable model in the study region. The total population of district khyber is 986973 and area is 2576 km^2 with a population density of 383 persons per square km. The population along Bara river and Landikotal main stream is highly susceptible to flash flooding in district khyber.

Keywords: Flash flood; geo morphometric; Geographical Information System; Remote Sensing; sub-basin; susceptibility

Electrical properties of rare earth-doped Barium Titanate

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Samples of undoped $BaTiO_3$, BT were prepared by three mixed oxide routes; hand mixing, *HM* using a pestle and mortar, ball milling, *BM* using Y_2O_3-stabilised zirconia balls and planetary ball milling, *PBM* using tungsten carbide balls. The electrical properties of slow cooled (SC) and quenched (Q) BT material for *HM*, *BM* and *PBM* samples were studied by impedance spectroscopy, IS after heat treatments in air at different temperatures. IS measurements with application of applied voltage and in atmospheres of different oxygen partial pressure were used to determine the conduction mechanism. The application of bias voltage was used during IS measurements to separate Schottky barrier interfacial impedances from sample impedances. In general, two types of Schottky barrier can be detected: (i) barriers at electrode-sample interfaces due to Fermi level mismatch and (ii) barriers between grains associated with partial oxidation of sample surfaces. In-Ga electrodes were considered to yield *ohmic* contacts and associated with partial oxidation that also produced the positive temperature coefficient of resistance, PTCR effect. A methodology has been developed to understand the effect of an applied voltage and changing oxygen partial pressure on electrical properties and possible explanations. Rare earth dopants can occupy either Ba or Ti sites or a mixture of Ba and Ti sites depending on their size. This requires charge compensation mechanisms which can be ionic or electronic. The ionic mechanism can involve either cation or oxygen vacancies. A survey has been carried out of the charge compensation mechanism for different rare earth ions (Gd, Dy, Ho, Y, Er and Yb). It was found that Y^{3+} preferentially occupied the Ti^{4+} site with charge compensation by oxygen vacancies and therefore, Y behaved as an acceptor with solid solubility limit of ~ 15%. Y^{3+} can also simultaneously occupy both Ba and Ti sites with a solubility limit of ~ 7.5%, but exclusive occupancy of Ba sites is limited to ~ 1.5%. A partial phase diagram BaO-TiO_2-Y_2O_3 can been presented showing the different solid solutions and the polymorphism of doped $BaTiO_3$. Several parameters affected the electrical properties of pure and doped BT ceramics: the charge compensation mechanism, whether ionic or electronic; the sample preparation methods; the cooling rate at the end of sample heat treatment because many samples lost a small amount of oxygen at high temperature and showed n-type semiconductivity. A common observation was that many slow cooled samples showed weak p-type behaviour attributed to uptake of oxygen on cooling. The holes may be associated with either underbonded oxide (O^-) ions or unavoidable impurities such as Fe^{3+}. Leaky dielectric properties were observed for extrinsic n-type region whereas, normal dielectric properties were observed for extrinsic p-type region. The electrical properties of $BaTi_{1-x}Y_xO_{3-x/2}$ samples fired and cooled in air were ferroelectric insulators at $x \leq 0.05$ and relaxor ferroelectrics at higher x with no evidence of semiconductivity in any of the samples, whether they were cooled slowly or quenched from high temperatures (1200-1600 °C). The possible occurrence of a resistivity minimum in rare earth doped BT was investigated. Three possible mechanisms for semiconductivity were considered for generating Ti^{3+} ions: direct donor doping, oxygen loss at high temperatures and a more complex double doping mechanism involving Y^{3+} and Ti^{3+} ions to charge-balance the oxygen vacancies. No semiconductivity and resistivity minimum were observed for Yb-BT for all three joins and Er-BT. Semiconductivity was observed

for other RE dopants and the total resistivity passed through a minimum at 0.1% RE substitution then increased generally for > 1% Y, Ho, Dy and Gd substitution on all three joins.

Keyword: Rare Earth doped; Barium Titanate

Groundwater and soil analysis with impacts of fertilizers for future hazards using remote sensing techniques: a case study of district Larkana

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Pakistan has an arid and semi-arid climate so various plants grow in different seasons. Soil contains mixture of micro (Boron, Chlorine, Copper, Iron, Manganese, Zinc, Nickle, etc.), macro (Nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur,) and non-mineral (from air and water are Carbon, Hydrogen, oxygen) elements which are essential for plant growth. Due to excessive use of nitrogen groundwater used for drinking gets contaminated by nitrate leaching which causes toxic effects to the urinary and digestive tract and cause inflammation. Heavy non-organic metals absorbed by vegetables cause health hazards. In soil nitrification by microorganisms occurs with access use of fertilizers around 50% of nitrogen is used by the plant, 20% is lost by evaporation, 20% reacts to organic compounds present in the clay, and 10% interferes with ground and surface water due to negative charge of nitrate it can leach to groundwater easily. Eutrophication is also a negative effect of fertilizers it causes algae which degrade water quality and its life. Fertilizers increase pH levels in the soil. Soil health is important because the soil does not support plant and provide life gas oxygen and also participate in the economy of the country. Soil health is relying on three parameters chemical (pH, Soil Salinity, organic matter), mechanical (texture of soil), and biological (microbial activity). Plants require 16 essential elements for their normal growth, yield and production. 13 are provided by soil including primary nutrients. and others provided them by fertilizers. According to the Soil survey of Pakistan Report parent material of Larkana's soil is alluvial deposits of piedmont and river plains. Average ranges pH 7.95, EC 0.4 ds/m^1, organic matter 0.88, phosphorous 4.74 ppm, and average extractable potassium 156 ppm. Larkana soils are low in organic matter. Larkana has 4 Talukas but Ratodero Taluka is highly vulnerable to salinity specially Ratodero taluka where rice is major crop. Soils of Ratodero were found calcareous due to calcium carbonate content. Larkana is irrigated by Dadu and rice canal mostly flows by river Indus which is reduced in size due to cementation. A huge amount of irrigation water is lost due to seepage and unmanaged pattern which causes Salinity and water logging in different areas which affects agricultural production and makes land unproductive. Most peoples of Larkana use groundwater for drinking purposes but overall 27.9% of areas use unsuitable groundwater for consumption 13.95% of areas use bitter taste and are contaminated. Groundwater, soil, and fertilizers were categorized with the problem, evaluation, and mitigation analysis in the Analytical hierarchy process (AHP).

Research comprises ArcGIS techniques to provide impacts of climate in RAI, NDWI, LST, SPI, impacts of soil texture in NDVI, NDMI, and water analyses with NDWI techniques. Primary data was conducted through surveys and questionnaires. Secondary research articles and agricultural census. 50 people were interviewed, and 70 online questionnaires were accumulated which results Larkana is vulnerable to climate change, water shortage, and the quality of water is not good. Fertilizers impact on health and food quality said 90% of surveyors.

Keywords: Groundwater; fertilizers; Soil; Larkana; Nitrification

Assessment of antimycotic potential of medicinal mushrooms against two agricultural soil born disease causing Fungal Pathogens - A sustainable agriculture

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The present research work explored antifungal potential of medicinal mushrooms against two notorious soil borne pathogens present in crop fields of sub-division Samahni District Bhimber, Azad Jammu and Kashmir (AJK). Four mushrooms were selected for antifungal activity to minimize the disease severity of two soil borne pathogens. Agar Well Diffusion Method (AWDM) was used for these in-vitro antifungal (IvA) activities. Our findings indicated that methanolic extract of *Schizophyllum commune*, *Trametes hirsuta*, *Ganoderma lucidum* and *Ganoderma tsugae* had better antifungal potential than that of diethyl ether, chloroform, and distilled water extracts against two crop damaging pathogens (*Fusarium oxysporum* and *Rhizoctonia solani*). It was also documented that methanolic extract of *Schizophyllum commune* against *Fusarium oxysporum* showed maximum zone of inhibition (ZI) which is 9.67±0.60 and *Rhizoctonia solani* also indicated highest ZI (5.67±0.88). Similarly, greater ZI (1.83±0.33) of *Trametes hirsuta* extract appeared in methanolic extract against *Fusarium oxysporum*. *Ganoderma lucidum* metabolic extract also indicated very effective results with ZI 7.83±0.44 and 8.83±0.60 against *Fusarium oxysporum* and *Rhizoctonia solani* respectively. Fourth selected medicinal *Ganoderma tsugae* macrofungi also showed maximum ZI against *Fusarium oxysporum* (2.50±0.28) and *Rhizoctonia solani* (6.50±0.28). Finally, it was concluded that the extracts of *Schizophyllum commune* mushroom greatly reduced the growth rate of soil borne micro-pathogens as compared to other tested species. The eradication of soil borne fungal species through medicinal mushrooms application will improve the growth of crops and ultimately increase the yield of crops as a sustainable agriculture.

Keywords: Antifungal Potential; Medicinal mushrooms; Fungal Pathogens**;** Agar Well Diffusion Method; Sustainable Agriculture

Medicinal potential of *Butea Monosperma* and *Calotropis procera* petals extract against prominent fungal diseases of wheat crop to improve yield for Sustainable Agriculture

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The present study documented the dominant fungal diseases of wheat crop and their biological management by using petals extract of two medicinal plants '*Butea monosperma* and *Calotropis procera*' for better production of wheat crop. Highest infection rate (57.14 %) was observed against *Fussarium graminearum* while minimum infection rate (20.8 %) was observed against *Blumeria graminis tritici* pathogen. The highest severity rate was recorded 80 % while the minimum severity rate was recorded as 40 %. The antifungal action of two plant's petals crude extracts have been applied against the dominant identified fungal pathogens during lab and field experimental trials. The highest zone of inhibition was observed in methanolic extract of *Butea monosperma* petals against fungi *Alternaria triticina.* Similarly, the maximum zone of inhibition was observed in methanolic extract of *Calotropis procera* against fungi *Fussarium graminearum*. It was indicated that the treated wheat plants produced better yield than non-treated plants. It was observed that the *Calotropis procera* showed better management of fungal diseases than *Butea monosperma.* So, it was concluded that the *C. procera* petals are more efficient because they have rich chemical compositions. Therefore, these are very effective against selected fungal pathogens. The biomanagement of severily effected wheat diseases of fungal species through petals of two medicinal plants crude extracts increased the yield of wheat crop.

Keywords: Antifungal Potential; Sustainable Agriculture; Medicinal plant; *Butea monosperma*; *Calotropis procera*; Fungal Diseases

Imbalance ecological system, local factors, disease and geography

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The environment is a matter of general concern. This is the basic attribute on which the life and economy system is built and hence is of vital importance. The balancing factor in the environment and human relationship is multi-dimensional and complex. New ecological systems have been formed; urbanization, industrialization and other patterns like social organization. All are characters and a component of the ecological system. Better health status is maintained by a balanced diet and a clean and hygienic environment. The world population is increasing day by day. The symbiotic relationship between man and the environment is known as an ecological imbalance. To meet people's demand, the combined effect of the two in most case lead to ecological imbalance. In certain parts of the world, deforestation is encouraged by environmental conditions and substantially influenced by local factors. Factors like anxiety, deforestation and depression highly impact health and results declare in form of the disease. Local particulars like expenditures, and maladjustment patterns like price and pressure. Coach stands, long routes, fuel discharge in form of smoke, and polluted air impact human health. The imbalance of socio-economic conditions and cultural disparities are agents of torture. Planning and designing rough surfaces, commercial nets and inadequate techniques promote mental stress. Pollution like rubbish and dirt heaps pollute the environment of the circle. Viral pressure caused infection and disease. Cultural disparities misfit social values, behavior, clash and injury indicate research patterns. Values and composition, early marriage, intermarriages, genetic print, and misfit organisms promote abnormalities and troubles. Atomic exposure, and experiments, badly impact human health. Natural calamities like earthquakes, and severe climatic conditions. Uncertainties are major troubles. Diagnosis recommendations and relevant issues present the composite picture of the research design.

Keywords: Environment; Disease; Imbalance Ecological System; Population Diagnoses

Identification of potential natural aquifer recharge sites in anjkora river basin, Pakistan, by integrating GIS and RS techniques

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Pakistan is the 4th biggest groundwater puller in the world. Its annual groundwater withdrawal is assessed at 65 BCM (Billion Cubic Meter), and its yearly sustainable groundwater assets are assessed at 55 BCM. The need for water is mostly fulfilled through groundwater sources, such as water bores and commercial tube wells. Hence, identifying recharge sites for natural aquifers is a significant component of groundwater required to overcome the water crisis. Therefore, this study aims to identify potential sites for natural aquifer recharge by using Multi Influencing Factor (MIF), and fuzzy logic methods. To achieve the stated objective, seven local influencing factors including soil, slope, water table, population density, land use land cover (LULC), drainage density, and elevation have been utilized in this study. MIF was utilized for the evaluation of the relative importance of the above-mentioned factors, while fuzzy logic was applied for the standardization of these factors. Finally, the MIF and fuzzy logic approaches were used to merge factor maps to identify suitable sites for natural aquifer recharge in Panjkora River Basin. Two different suitability maps were constructed from both techniques, and on each of the resulting maps, the subregions were categorized into five classes: not suitable, less suitable, moderate, suitable, and most suitable. Based on the MIF results, 25% of the whole study area is deemed most suitable for natural aquifer recharge (NAR), whereas from the fuzzy logic results, 30% of the study area is marked as most suitable. In contrast, 20% and 32% of the whole study area were identified as suitable by the MIF and fuzzy logic methods, respectively. While both techniques can obtain satisfactory outcomes, the suitability map from fuzzy logic has produced more precise results. The results of the study were recommended to soil and water conservation and agriculture engineering department to construct the recharge wells.

Keywords: Multi influencing factor; Geographic information system; Groundwater; Fuzzy Overlay; Arc GIS

Delineation of suitable areas for ground water recharge facilities in district Dera Ismail Khan, Khyber Pakhtunkhwa using geospatial approach

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Water acts as the most necessary feature in daily lives which is reducing at a higher rate in both rural and urban areas, and the reason is rapid growth in farming and household necessities. Hydrological modelling subsurface water acts as the most important feature because of shortage. The research is based on both lab work and field work. A field survey has been conducted to verify all the results. Different aquifer recharge influencing parameters i.e., LCLU, rainfall, Lineament density, Drainage density, Elevation, population density, Watertable, slope, geology and soil texture were selected. Two techniques were used in this study i.e., mathematical approach and fuzzy overlay. Results from the weighted overlay analysis using mathematical approach revels that 78.20 km^2 area having very high Potential, 786.03 km^2 area having high, 1175.23 km^2 moderate and 330.07 km^2 having poor potential for recharge. On the other hand, in the fuzzy overlay technique same number of parameters were used in fuzzy overlay analysis. Result from the fuzzy overlay analysis revels that 90.80 km^2 area is categorized as very high, 580.56 km^2 area as high, 1210.32km^2 as moderate and 407.78km^2 having poor recharge potential. This work is of significant importance for the soil and water conservation strategies in order to harvest and recharge the aquifer.

Keywords: Remote Sensing; Rainwater Harvesting; Conservation; ArcGIS; MIF

Annual soil erosion assessment using geographic information system and revised soil loss equation: A case study of district Nowshera Khyber-Pakhtunkhwa

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The erodibility of soils is a worldwide issue that is a big threat to all the reserves specifically in parched regions, which refers to surface debasement. A total of eighty percent of agrarian land is exposed to abrasion ranging from moderate to extreme, which eventually leads to a reduction in yield. The Revised Universal Soil Loss Equation (RUSLE) has been modified from the Universal Soil Loss Equation (USLE) that was made for the estimation of erosion phenomenon in the farming lands of the United States. District Nowshera was affected by floods in 2009, 10, 11, 14, and the most recent Monsoon flood in 2022. After the flood of 2018 and 2022 mostly the agricultural land was eroded by rivers. In this study total of six factors i.e., soil erodibility factor, cover management factor, length and slope factor, support practice factor and rainfall erosivity factor were analyzed. Required data on these factors were collected from different sources and analyzed in the ArcGIS environment. The weighted sum tool located inside the spatial analyst extension in ArcGIS 10.4 Software was used to combine all six factors for the results generation. The potential of soil erosion in the Study area varies from 0.27 to 69 tons/hectare/year. Results are categorized into four zones. They are low (0.273 tons/hectare/year), moderate (0.274–1.36tons/hectare/year) high (1.37 - 3.54 tons/hectare/year) and very high (3.55- 69.5 tons/hectare/year). The total area of district Nowshera is reported 1686985651.17 Hectares (416863.23 Acres), in which a total soil loss of 167002.2 tons/hectare/year was observed in this study. It was found that nearly 98% of the total area is lying in moderate and high erosion prone zone. Verification of the outcomes was done and a field survey was conducted to identify very prone areas to soil erosion. Hand-held GPS devices were used to mark the exposed areas to soil erosion. It is concluded that GIS and remote sensing is an efferent tool that provides results in less time with low cost and labor.

Keywords: GIS; Remote sensing; RUSLE; Prone; Weighted

Effects of climatic drivers on traits divergence of *Juglans regia* L. population in Northern Pakistan

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Juglans regia L., is a nutritious fruit producing tree commonly found in the temperate zone and the northern hemisphere. Habitats of this species vary from wasteland, ridges to farm boundaries and forests. As this species grows extensively in northern Pakistan, particularly in three districts namely Dir lower, Dir upper and Swat districts, hence the Walnut population of these three northern districts has been explored in 44 sites for detecting the range of morphological divergence in their leaves and nuts. Climatic data was collected by a device "Professional Wireless Weather Centre" as well as from "Federal Department of Metrology Government of Pakistan". Walnut morphology was characterized through simple ruler and Vernier callipers, correlating climatic drivers with Walnut morphology. Our findings revealed that the shoot length (height) of Walnut in both districts of Dir vary from 33 to 67.2 feet, whereas the height of this species in district Swat varies from 35.37 to 61.3 feet. Similarly in both districts of Dir (lower & upper districts) the leaf length varies from 10.31 to 12.12cm and its width varies from 5.33 to 6.38cm, however, in district Swat the length of leaf varies from 10.12 to 12.23cm and its width varies from 5.24 to 6.47cm. Considering the nuts, in both the districts of Dir, the length of nuts, their width, thickness and weight varies from 31.13±0.21, 27.12±0.32, 25.0±0.24mm, 8.11±0.24gm to 43.23±0.11, 37.91±0.82, 36.92±0.84mm and 9.95±0.21gm respectively, whereas in district Swat these values for these parameters vary from 30.45±0.12, 26.22±0.22, 26.11±0.1mm, 8.18±0.9gm to 44.22±0.41, 36.24±0.14, 33.24±0.33mm and 9.91±0.87gm respectively. Plant height was maximum in low altitudinal areas of 778 meters above the sea level (e.g., in Rangila and Balo Rabat areas), while it was minimum at high altitude areas of 2804 meters (above the sea level e.g., in Malam Jaba and Laram areas). The height of plants, leaves length, nuts length and weight have significant variation to their environment ($P < 0.05$). The study reveals the effect of climatic and edaphic drivers (temperature, precipitation, soil temperature, altitude etc.) on the morphological variation of *Juglans regia* L., and to know their proper growth and development growing in the forest ecosystems of north western Pakistan in the Hindu Kush Himalayan junction.

Keywords: Leaf width; Nutritious; Climatic; Population; Conservation; Forest ecosystem

Mineralogical, textural and weathering controls on the physical and strength characteristics of intrusive rocks from North Pakistan

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The utilization of intrusive igneous rocks for construction and decorative purposes depends primarily on the mineralogy, texture and weathering grades. This study evaluates these properties of intrusive igneous rocks from north Pakistan and show how these factors affect the rocks' physical and strength characteristics. In comparison to the felsic rocks, the mafic and intermediate rocks displayed low cumulative percentages of quartz, feldspar, and plagioclase as well as higher specific gravity, strength (i.e., compressive strength and Schmidt hammer values), and ultrasonic pulse velocity values. Likewise, samples with anhedral grain shape, irregular boundary, and fine to medium grain size displayed higher strength values, i.e., compressive strength (from 91 to 121 MPa) and tensile strength (from 9, and 12 MPa), respectively. The various weathering grades given to the samples under investigation, such as fresh, slightly weathered, and highly weathered, were in good agreement with their physical and strength characteristics. With the rise in grade, the porosity and water absorption increased (0.28% and 0.72% respectively), while the specific gravity, compressive strength, and tensile strength decreased (2.04, 20 MPa and 2.5 MPa, respectively). Rock strength is influenced by quartz content, but there was no explicit relationship between rock strength and the maximum and mean grain sizes of the various minerals. These findings can be used as a guideline for evaluating intrusive igneous rocks for construction and decorative purposes.

Keywords: Intrusive igneous rocks; Mineralogy; Texture; Weathering grades; Schmidt hammer; Ultrasonic pulse velocity

Petrographic and geotechnical characteristics of carbonate aggregates from Darwaza limestone and its suitability for the construction of road surface structures

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This research work involves a detailed physico-mechanical investigations of Darwaza Formation and correlations with international standards to find out its suitability as a construction material. Among the physico-mechanical parameters of studied samples, compressive strength values ranged from 11-33 MPa, water absorption ranged from 0.2 to 1%, porosity ranged from 0.13 to 0.55, specific gravity ≥ 2.5 i.e., 2.5 to 3.0. Similarly, Loss Angeles abrasion value was obtained as 27.2 which is within the standard range. The shape index of the studied aggregate samples was 5.8% (Flakiness Index) and 5.6% (Elongation Index) where the specified upper limit is 15%. Using sodium sulfate for determining the soundness test the total weight loss in 5 cycles was 2.9, which is well within the specified range. Petrographic studies suggested these rocks are classified as micritic limestone or mudstone. Only a few dolomitic romes were observed that shows dolomitization at the very initial stages and neglects the alkali carbonate reaction, making them feasible for use as concrete aggregate. The absence of quartz minerals also suggests absence of alkali silica reaction, suggesting its suitability for asphalt aggregate. Although the fractures, joints and weak zones are noticed in the studied thin sections, nevertheless, the geotechnical parameters support it as suitable and feasible for the construction of road surface structures. Based on the detailed study of rock material and aggregates, it is inferred that the asphalt-concrete mixtures will be of good quality. This in turn assures the production of a durable road surface with an optimal thickness, which would be resistant to environmental factors. Such approach among producers of aggregates, asphalt, concrete and road surfaces should assure a sustainable development and satisfaction of road users.

Keywords: Aggregates; Darwaza Limestone

Unconventional natural gas plays in Pakistan: opportunities and challenges

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The share of natural gas contribution to Pakistan's energy mix was 41.81% for the year 2021, thus reflecting the huge dependence on natural gas. The rapid exhaustion of these reserves in Pakistan has reduced the reserve-to-production ratio (RP ratio) for not more than 15 years. Over the last few years, the country has faced rapid and regular shortfalls in natural gas supplies, forcing authorities to begin importing liquefied natural gas (LNG), mainly from Qatar. Since natural gas infrastructure in Pakistan is well established, future energy directives must include a substantial research and development efforts towards exploration and exploitation of alternative and unconventional natural gas resources, which have already acquired the status of 'game changer' in the international energy market. Although relatively unexplored, the Thar coalfield is the largest lignite resource of Pakistan, representing 94% share of total coal reserves in the country. The prospects of coalbed methane (CBM) have been shown on an empirical basis for some time, however, limited progress has been made thus far. The geology and rank of the Thar coalfield have been found to be analogous to other methane producing coalfields in the region including the Barmer Basin and Cambay Basins (India). The Cambay Basin, a kind of extension of Thar, has been reported to be fairly high in CBM content at greater depths and the Barmer Basin, which lies in the Thar Desert of Indian Rajasthan, has a gas content ranging from 3 to 4 m^3/ton. A number of studies have also indicated that the geological stage of Thar lignite may be susceptible to biogenic methane generation. Likewise, few organic rich shales have been prospected in Pakistan, recently. The technically recoverable shale gas resources of Pakistan has been estimated to be as large as 105 Tcf by US Energy Information Administration (EIA). The geologic setting of Southern and Central Indus Basins, which are located along the western borders of Pakistan with India and Afghanistan, are potential source of significant volumes of shale gas. The main source rock in the Lower Indus Basin is the lower Cretaceous Sembar Formation, which contains silty shale, shale and marl. These prospects provide an opportunity to initiate the exploration and exploitation of this alternative energy resource, which could provide a source-resource for the applications of conventional as well as novel technologies such as the stimulation or regeneration of methane through biological applications. Developing subsurface biogenic methane as an alternative source of natural gas has tremendous potential as well as challenges including regulatory, production costs and market demand. However, a major and extensive development program is required to harness this new resource. Ultimately, this development may ensure a more 'carbon-lean' energy mix for the country as opposed to the prospective of increased coal use.

Keywords: Unconventional natural gas reserves; Biogenic methane; Shale gas; Carbon lean energy mix; Energy security

Lithium-bearing pegmatites in the greenstone belt of the Archaean craton in Zimbabwe, Africa

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Lithium-Cesium-Tantalum (LCT) type pegmatites are granitic rocks that form relatively small igneous bodies and are characterized by large crystals and a variety of distinctive textures. The LCT family of pegmatites takes its name from its characteristic enrichment in lithium (Li), cesium (Cs), and tantalum (Ta). Lithium in these pegmatites is extracted from lepidolite, spodumene and petalite. These LCT pegmatites account for about one-fourth of the world's total lithium production, most of the tantalum production, and all of the cesium production. These are distributed worldwide including Australia, Afghanistan, Argentina, Brazil, China, Chile, Canada, Nigeria, and Zimbabwe.

Africa has extensive lithium resources mostly in the LCT-type pegmatites. The Li-bearing pegmatites are typically tens of meters thick and hundreds of meters long. Zimbabwe is having the largest hard rock lithium reserves in Africa. The main Li-producing mine in Zimbabwe is Bikita Mine. Other pegmatites with Li resources include Arcadia, Kamativi and Zulu regions. Most of the Li-bearing pegmatites are in the greenstone belt of the Archaean Craton and are similar to the Li pegmatites of Australia. However, the Li-bearing pegmatites of Kamativi arenotably younger and more similar to the pegmatites of the Namaqualand in Namibia and South Africa.

The Bikita mine is located about 350 km south of Harare and is the most productive mine of lithium. The ore minerals in the Bikini mine include petalite, spodumene, lepidolite, tantalite and pollucite. Spodumene resource of 13 Mt with > 1.6% of Li_2O has been identified. This resource of Archaean in age, is characterized by complex zonation and some classic pegmatitic texture.

The Li-bearing pegmatites of Archaean in age in Arcadia occur about 3 km south of Harare. These are stacked flat-lying pegmatites mainly containing petalite and spodumene. The Li reserve have been identified as 37.4 Mt with 1.22% Li_2O. .

The Li-bearing pegmatites of Proterozoic in age in Kamativi are located about 700 km west of Harare. Spodumene is the main Li-bearing mineral in Kamativi with resources of 26.32 Mt @ 0.58% Li_2O content. These types of pegmatites are common throughout the Dete-Kamativi area.

Keywords: LCT-type pegmatites; Lithium; Zimbabwe; Bikita, Arcadia; Kamativi

Petrographic and geo-mechanical investigation of diorite rocks from district Bajaur, North West Pakistan

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Common igneous rocks such as granite and diorite are widely used as building materials and dimensional stones. The granite-diorite deposits in Pakistan are estimated to be 297 billion tons of various colors and textures. Six samples of diorite from the Pashat area of district Bajaur, NW Pakistan were examined for petrographic and physico-mechanical parameters.

Petrographic investigation revealed that all samples are mega porphyritic. The rocks contained varying amounts of dominant mineral phases like plagioclase, quartz, amphibole while biotite, muscovite, chlorite, and opaque ore grains constitute the minor phases. Rocks are mostly composed of plagioclase (60%), quartz (14%), amphibole (13%) and biotite (10%), along with chlorite (1%) and opaque (2%). Polysynthetic twinning and undulose extinction are commonly observed in plagioclase and quartz grains respectively. Some euhedral to subhedral plagioclase grains exhibit worm-like intergrowths of quartz resulting in a myrmecitic texture. Amphibole phenocrysts are dominant in the matrix of quartz and plagioclase feldspar with an average abundance of 11%. At places, these phenocrysts show dominant chlorite alteration and are fractured.

The coarse grain texture and no significant alteration in the studied samples have a positive effect on rocks mechanical properties. Following a comprehensive petrographic analysis, their uniaxial compressive and uniaxial tensile tests (UCS, UTS) as well as their physical properties (porosity, water absorption and specific gravity) were determined. The values obtained for unconfined compressive strength (UCS) ranging from 40.4 to 97.9 MPa, unconfined tensile strength (UTS) ranging from 5.03 to 10.10 MPa, water absorption ranging from 0.04 to 0.76%, porosity ranging from 0.01 to 2.28% and specific gravity ranging from 2.871 to 2.893%. Based on UCS-derived and UTS-derived parameters, the studied rocks fall into the category of moderate to strong suggesting its suitability for using as dimension stone. Besides this, these rocks are more durable largely attributed to their low water absorption and porosity values. Based on both petrographic and physio-mechanical data, Pashat diorites rocks in the studied area are suitable for building stone, decorative stone. However, they can't be used as an aggregate because of more than 5% strained/undoluse quartz which makes them susceptible to alkali-silica reactivity and must be considered before using in high performance concrete.

Keywords: Diorite; Bajaur; UCS; UTS

Renewable energy in agriculture: a mitigation strategy to climate change & energy crisis in Pakistan

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The use of fossil fuels for power generation has severely damaged the global environment. It is evident from current temperature rises & global warming that humans are responsible for disturbing the environment. These climate changes are more evident in the South Asian region. Globally, agriculture contributes about 30 % of human-caused greenhouse gas (GHG) emissions because of its heavy land, water, and energy use that's more than every car, train, and plane in the global transportation sector. Livestock farming alone contributes around 18 % of GHG emissions, including 9 % of carbon dioxide, 35 % of methane, and 65 % of nitrous oxide. Activities like running fuel-powered farm equipment, pumping water for irrigation, raising dense populations of livestock in indoor facilities, and applying nitrogen-rich fertilizers, all contribute to agriculture's high GHG i.e. footprints. Pakistan is among the countries facing an energy crisis. The main cause of the energy crisis directly refers to the natural problem of scarce resources. As the whole world has scarce natural resources that are depleting with every tick of the clock, the chance of converting natural assets into electrical energy is decreasing day by day. Another problem increasing the energy cost is becoming a serious issue in the field of agriculture. In Pakistan, the energy crisis is the single largest drain on the economy, which cuts gross domestic product progress by more than 2 % each year. Due to the high cost of diesel and electricity and frequent shutdown of electricity, pumping groundwater has become uneconomical. Solar and biofuels are alternative energy sources that can help overcome this issue. Pakistan's agriculture sector has a high potential for renewable applied and new energy resources. In agriculture this is the need of time, to minimize carbon emissions and help to fight the climate and energy crisis. Government should make policies and integrate agriculture research with an agricultural extension so all these solutions can be disseminated to end users using different agricultural extension approaches. As renewable are costly, agricultural finance institutions can play an active role in the adoption of these renewable technologies (solar pumps, solar-powered drip irrigation systems, biogas plants, solar dryers for agricultural products, etc.) through its green banking financial products.

Keywords: Green technologies; Sustainable agriculture; GHG emissions; Alternative energy sources

Depositional modeling and shale gas potential of the Sembar Formation in the Sulaiman Range, Pakistan

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The Sembar Formation in the Sulaiman Range has a thick succession of black to dark-gray shale. The lithofacies analyses based on field observations, petrography, scanning electron microscopy (SEM), backscattering electron microscopy (BSEM), and energy-dispersive x-ray spectroscopy (EDX) are done for depositional modeling of the formation. The analyses reveal the presence of calcareous shale lithofacies, siliciclastic shale lithofacies, and argillaceous shale lithofacies, representing deposition of Sembar Formation in coastal to inner shelf settings. The organic geochemical source rock analysis yield favorable total organic carbon (TOC) and Rock Eval results, showing the presence of both Type II & III kerogens, which are capable of producing gas. Few beds exhibit poor to moderate quality source rock, as indicated by low TOC and Rock-Eval values. The T_{max} versus hydrogen index (HI) values reveal that some of the beds are thermally mature at current outcrop levels. The TOC values, thermal maturity, bulk rock mineralogy and formation thickness reveal that the Sembar Formation is having brittle nature, i.e., abundance of quartz as compared to clays, and is capable of fracking process, indicating that the Sembar Formation is having very good potential to serve as unconventional shale gas reservoir, particularly in the northern part of the Sulaiman Range.

Keywords: Sulaiman Range; Sembar Formation; TOC; Unconventional shale gas reservoir

Hydrological conditions and water quality assessment during construction and operation of the Lowari tunnel in Pakistan

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This study outlines the hydrological conditions that were encountered during the construction and operation stages of the Lowari Tunnel in Pakistan. The study analyzes the water conditions inside the tunnel during its construction, evaluates the dewatering rate, and assesses the water inflow after the completion of the tunnel. The study also examines the suitability of the tunnel water for drinking and irrigation purposes and its impact on the tunnel support systems. The tunnel was constructed in a challenging area characterized by heavy snowfall, landslides, and rockfalls. The water ingress in the tunnel was significant during the excavation and operation stages, and the study assesses various factors such as water source, quantity, color, and odor. The tunnel was divided into dry, damp, dripping, and flowing sections, and the dewatering rate was recorded during excavation. The study found that the water was appropriate for utilization in the support systems of the tunnel, such as concrete and steel installations. However, the water discharged from the southern portal of the tunnel was deemed unsuitable for drinking, owing to its low pH value. The findings of the research offer significant implications for comprehending the hydrological characteristics of the Lowari Tunnel, as well as for the sustainable utilization and management of water resources in future tunnel construction projects in the region.

Keywords: Lowari Tunnel; Drinking Water

Petrographic and mechanical characterization of Kumrat granite: Correlation between destructive and non-destructive testing techniques

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The Kumrat area, located in the Khyber Pakhtunkhwa province of Pakistan, is a part of the Kohistan batholith, which constitutes the southwestern portion of the intra-oceanic Kohistan island arc. Kumrat granite of this area is analyzed in terms of its petrographic features and mechanical properties using destructive and non-destructive techniques. The field observations and petrographic studies of representative samples revealed that the granites are sub-equigranular to in equigranular, coarse to medium-grained, and exhibit no preferred orientation. The granites consist mainly of alkali feldspar (mostly orthoclase), quartz, and plagioclase with accessory amounts of biotite, chlorite, muscovite, sericite, opaque ore mineral, and trace amounts of sphene. The quartz was mostly strained and showed strong undulose extinction. Chlorite was observed as a secondary mineral, formed through alteration of biotite. The mechanical and physical properties of the samples, including uniaxial compressive strength, uniaxial tensile strength, specific gravity, porosity, and water absorption, were determined for different textural varieties of the rocks. The average compressive strength for coarse and medium-grained varieties were calculated as 56.5 MPa and 78.9 MPa, respectively that fall into the category of strong rocks. The values of specific gravity, porosity, and water absorption were within the permissible range for their use as construction material. Non-destructive testing revealed a significant positive correlation between ultrasonic pulse velocity and Rebound Hardness number and compressive strength, with acceptable correlation coefficients. The relationship between ultrasonic pulse velocity and water absorption and porosity showed that as pore space increases, there is a decrease in the velocity and vice versa. Likewise, the correlation of Schmidt Hammer with water absorption and porosity showed a good relation, where as porosity increases, there are higher chances of water absorption with a decrease in Rebound Hardness number value and vice versa. The detailed petrographic features, mechanical properties, and correlation of destructive and non-destructive techniques of the investigated rocks revealed that the medium-grained granites are slightly stronger than coarse-grained granites, probably due to their finer grain size. This study provides valuable insights into the properties and characteristics of Kumrat granite, which can help in its appropriate utilization as a construction material.

Keywords: Kumrat Granite; Uniaxial compressive strength;Uuniaxial tensile strength

Paragenesis and economic evaluation of the Mana Sar nephrite in prospect of mining, district Bajaur, Pakistan

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The study was conducted in District Bajaur in order to study the paragenesis and economic evaluation of the Nephrite. The chemical formula of Nephrite is $Ca_2(Mg, Fe)_5[Si_8O_{22}] (OH)_2$. It can be composed either of iron-rich (actinolite) or magnesium-rich (tremolite) varieties. Its colour varies from onion-green to greenish-Gray, white, pinkish, yellowish, bluish to black depending on iron content and some admixtures of other minerals (serpentine, chlorite, calcite, magnesite, and talc). Nephrite have a hardness of 6 to 6.5 on Mohs scale, monoclinic crystal system and specific gravity ranging from 2.95-3.21 g/cm^3. During field work, three main veins were identified as V1, V2 and V3. The parageneses of the nephrite veins were Metasomatic replacement of serpentine. All of three veins were of low to medium quality. The hardness of the veins increases with depth, which is a good sign for mining. All of the veins can be accessed through a single link road, making them easily reachable. The veins are located within a distance of 500 meters. V1 has a dipping angle of N05W/38W degrees, which makes excavation easier due to its location on top of the mount. V2 is a wedge shape dipping having N76E/86N, and V3 has two units that have a hardness of 4 to 5 within 3ft. All of the veins have open space for dumping material, which is cost-effective. There are different sets of joints in the veins, including along the bedding, across the bedding, and some cross-joints. It is believed that the amount of deposit may be much higher than estimated due to changes in inclination with depth. All of the visited veins are of the lensed type, which is known to produce the best quality nephrite in the world.

Keywords: Nephrite; Paragenesis; Mohs Scale; Economic Evaluation

Surfactant functionalized silver nanomaterials as sensors for the detection of mercury in aqueous samples

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Mercury, a worldwide pollutant from natural or anthropogenic sources, can be globally transported and released to the environment.The aim of this study was to develop an analytical method for the determination of mercury in aqueous samples. Most analytical methods reported for the quantification of mercury require complex procedures and expensive equipment, in the work, a simple and sensitive protocol has been developed for the determination of mercury using room temperature synthesized and Brij-35 modified silver nanoparticles. The addition of mercury to nanoparticles followed a linear response and changed the absorbance in two concentration ranges from 0.5 to 2 μ mol L^{-1} and 50 to 200 μ mol L^{-1} with limit of detection (LODs) of 5.5 $x10^{-8}$ and 6.3 x 10^{-6} mol L^{-1} respectively, while the correlation coefficient was approaching unity. The higher concertation from 50 to 150 μ mol L^{-1} also induced spectral shift (blue shift) with LOD of 2.6 $x10^{-7}$ molL^{-1} correlation coefficient of 0.997. The reproducibility of the sensor was accessed by relative standard deviation that was below 10 %. Determination of mercury was successfully made in tape water after spiking with two concentrations and satisfactory recoveries were obtained. The performance of the sensor showed that it can be applied to the determination of mercury in real samples.

Keywords: Mercury; Silver nanoparticles; Standard deviation

GIS-based earthquake potential analysis in Northwest Himalayan, Pakistan

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The present study focuses on the use of integrated remote sensing and the Geographical Information System (GIS) approach for the identification of earthquake potential areas. In the adopted approach Sentinel-2 and Shuttle Radar Topography Mission (SRTM) satellite data, earthquake data, and geological data are used. Important factors related to earthquakes were recognized and relative input data layers (digital elevation model, slope, earthquake magnitude, epicentre location, lineaments, faults, distance to active faults and epicenter) were developed. For data integration in GIS, a numerical ranking scheme has been adopted to establish rank values for each factor for the appraisal of earthquake potential index (EPI) map. The final earthquake potential index map divides the study region into different corresponding potential classes: high, moderate, low, and very low. The earthquake potential map produced for the region was compared with the previous seismic hazard maps derived from traditional techniques. The use of various parameters and implementation of the suggested method in the study region elucidates its good and detailed estimation of earthquake potential areas compared to traditional techniques.

Keywords: Remote sensing: GIS; Lineaments; Earthquake potential index; Northern Pakistan

A GIS-based assessment of Earthquakes in Pakistan from 2009-2019

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Pakistan is seismically most dynamic and active zone of Central Asia and has experienced many devastating earthquakes. In this study an updated and unified earthquake catalogue has been developed for Pakistan having latitude (24-37°N) and longitude (61-75.5°E). This catalogue covers a period from 2009 to 2019. Data from United State Geological Survey (USGS) was used for the compilation of this catalogue. The new catalogue is homogenized to moment magnitude (Mw), because a homogenized and uniform earthquake catalogue is an essential tool in any seismic hazard analysis. For the homogenization of the catalogue in term of moment magnitude Scordilis global relations 2006 formula was used. This formula was used for conversion of Body wave magnitude, and Local magnitude to Moment magnitude and Gutenberg and Richter (1956) relation for the local magnitude. After the homogenization the earthquake data was plotted on maps to observe the occurrence of earthquakes on the basis of magnitude and focal depth. From these maps it is identified that Main Boundary Thrust (MBT), Jehlum fault, Balakot-bagh fault, Raikot fault and Ornach-nal fault are active seismically and producing smaller to moderate magnitude earthquakes. Similarly mostly shallow earthquakes (depth<70 Kilometers) were observed all over Pakistan while in North-west of Pakistan moderate level earthquakes were noticed.

Keywords: Earthquake assessment; Moment magnitude; Scordilis equation, Pakistan

Biosystematic studies in mushrooms of the moist temperate pine forests of Swat, Pakistan

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This study describes morphological and molecular phylogenetic investigation of the mushrooms of Miandam, district Swat, a floristically rich and diverse region of Pakistan. Miandam is an area of diverse vegetation and ecosystem types. For exploring mycobiotic diversity of the area field surveys were conducted during rainy seasons of 2021–2022 for collection and documentation of mushrooms. A sum of 20 fruiting bodies of mushrooms were collected and preserved from the study area. Among the collected mushrooms, 15 samples were subjected to DNA analysis. A total of 12 out of 15 specimens amplified successfully during Polymerase Chain Reaction, while only 7 among the amplified ones yielded editable nuclear ribosomal ITS sequences which were further subjected to morphological and molecular biosystematics studies. Among them 9 taxa belonging to 6 families are described in this work. The mushrooms family, Russulaceae represented by 3 species and Agaricaceae and Boletaceae represented by 2 species owe their leading positions. Other families like Hygrophoraceae and Inocybaceae are represented by one species each. Among the taxonomic description one species *Inocybe umeriana* nom. pro. seems new to science, six species via; *Floccularia luteovirens, Floccularia albolanaripes, Strobilomyces minor, Russula anatine* and *Russula sanguinea* and *Xerocomellus diffractus* are new records for Pakistan whereas two species via; *Hygrocybe conica* and *Russula delica* are already reported from Pakistan. The phylogenetic analysis of these species with other similar taxa from different parts of the world has been presented.

Keywords: Mushrooms; Hygrophoraceae; boletaceae

Integrated geophysical and geochemical study of Tattapani thermal spring: Implications for Geothermal Power Generation

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This study investigates the potential for geothermal power generation in the Tattapani thermal spring using geological, geophysics, and geochemical techniques. Based on the resistivity survey four distinctive lithological units, with the high resistivity unit representing weathered dolomite/limestone and the low resistivity unit being related to hydrothermally altered rocks were delineated. The thermal spring is concentrated on the right bank of the river Poonch at a depth of 30m below the surface, increasing in depth in the Northeast direction. Fresh groundwater is mostly concentrated in sandstone and dolomite and lies above the thermal plumes, which are highly prone to contamination. The thermal spring is characterized by the source of recharge being surface runoff and perennial Poonch river. The heat source is Precambrian shield rock derived heat from the mantle source for thermal convection cell. The thermal spring oozes along a discontinuity, weaker zones faulty zone between Cambrian Abbottabad Fm and Paleocene Patala Fm acting as a conduit for thermal convection cell. A pilot drilling is recommended below to a deeper level of 500 m for actual thermal temperature, geotechnical study, and assisted by gravity for a detailed basin analysis of the Tattapani thermal regime. Overall, this study provides valuable insights into the subsurface properties and potential of the Tattapani thermal spring for geothermal power generation.

Keywords: Tattapani, Geothermal, Resistivity, Magnetic, Geochemical, Tectonic Regime

Landslide development characteristics and risk zoning along Dir road in Khyber Pakhtunkhwa, Pakistan

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Landslides are among nature's most devastating disasters. They are defined as earth movement down a slope, rockslide, rockfall, or debris flow. Landslides are considerably more dangerous in the mountainous terrains. The Karakoram Highway, in northern Pakistan is the main highway and only land route between China and Pakistan, however, it is prone to landslides and rockfalls. Landslides and mountain or hill slope failures are highly correlated, and such landslides pose greater threats to valleys as the vulnerability of mountain slopes increases due to weathering, deforestation, and other human-induced activities. Due to the wide range of landslide phenomena, no single method exists to identify and map landslides, to establish landslide hazards, and to evaluate the associated risk. This study aims to develop the landslide inventory, hazard and risk zones. SRTM 30-meter DEM and geographical information system (GIS) technology were used to create and analyze a spatial database of 2 landslides. To determine the significance of event-controlling parameters in triggering the landslides, a multi-criterion evaluation was used. The parameters included lithology, slope gradient, slope aspect, elevation, land cover, rivers, and roads. The goal of landslide studies is to reduce the negative effects of landslide hazards through risk evaluation. The data was analyzed to show that land sliding is the most common type of hazard in the Dir, Kohistan area, and the results revealed five classes of landslide risk zones. The areas exposed to hazards are distributed at random, with only 13% of the research area falling within the high-risk zone. A large portion of the land is classified as no or low risk, with 27% classified as moderate risk. Furthermore, it was found that lithology has the greatest influence on land sliding, especially when the rock is highly fractured, as in lavas, tuffs, agglomerate, slate, quartz diorite, and as the soil cover is sandy clay, which has a high angle of internal friction and less cohesion, may also influence landslides. Similarly, the proximity of the landslides to faults, rivers, and roads played a role in initiating failures. Landslides also occurred at elevations ranging from 1300 to 2100 meters, primarily on southeast and south trending slopes. Landslides were more likely in areas with few or no forested slopes than in dense forests. One-third of the study area is highly or extremely vulnerable to future land sliding and requires immediate mitigation action. The rest of the study area is relatively stable and has a low or moderate susceptibility to land sliding.

Keywords: Landslides, hazard, GIS, risk, susceptibility

Uncertainties in hydro-climatic modeling under changing climate

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The high climate sensitivity of hydrologic systems, the significance of these systems to society, and the imprecision of climate projections for the future, all stimulate interest in defining uncertainty in the hydrologic implications of climate change. It is now widely accepted that climate change will have immediate and long-term effects on the global availability and management of water resources. All hydrological models can be classified into three fundamental categories of uncertainty: measurement, structural, and parametric. Inaccurate measurements of variables and attributes contribute to the problem of measurement uncertainty (e.g., stream flows that are typically an output and rainfall that serve as an input to hydrological models). Inaccuracies in the mathematical representation of actual hydrological processes generate structural uncertainty. Insufficient calibration data and the inherent inaccuracy of structural and measurement-based approaches add to a degree of parametric uncertainty. Despite the fact that scholars have studied measurement and parametric uncertainties, there has been a paucity of research on structural uncertainty. To be more specific, there is no known model for determining the magnitude of structural uncertainty in an unmeasured area.

Keywords: Climate; hydrological model; uncertainty

Evaluating ASTER SWIR data for lithological discrimination and mapping in Kurram-Waziristan, Northwestern Himalayas, Pakistan

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This research work provides novel approaches for lithological mapping in Kurram-Waziristan, in the Northwestern Himalayan orogenic belt using data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). Reflectance data from visible near-infrared (VNIR), and shortwave infrared (SWIR) were processed and interpreted for mapping sedimentary units. Various methods i.e., Minimum Noise Fraction (MNF), Independent Component Analysis (ICA), Principal Component Analysis (PCA) and Band Rationing (BR) can be used for lithological mapping. This study involves calibrated ASTER (SWIR) data using the PCA and BR techniques. The area under study hosted numerous rock types, including limestone, shales, sandstone, dolomites, and siltstone, as well as continuous geological sequences. The efficiency of the proposed Band Combination (BC) for lithological mapping was demonstrated by its derivation from PCA (R: PC2, G: PC1, B: PC3) and BR for different minerals. In comparison to PCA the BR (R: B4/B7, G: B4/B1, B: (B2/B3)*(B4/B3)) performs well in discrimination of different lithological units. Lithological map derived from BR and PCA shows strong correlation between the published lithological map and results obtained from the field investigation. As a result, ASTER SWIR data combined with advanced image enhancement approaches i.e., PCA and Band Ratio are recommended as an efficient and cost-effective tool for lithological discrimination and mapping.

Keywords: Principal Component Analysis; Band Ratio; lithological mapping; ASTER

Demarcation of groundwater potential zones in Karak region using an integrated approach of geospatial and geophysical techniques

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Groundwater resource management is a difficult challenge everywhere due to the rising demand for water from various sectors, including domestic, industrial, and agricultural, as well as the depletion of available supplies. There are several options that may be taken into consideration to solve the abovementioned groundwater management challenges. In Pakistan, areas including the semi-arid and arid regions of South KP are facing water scarcity issues because of the depletion or decline of groundwater levels. The literature review suggests that single remote sensing and GIS methods were used for the identification of water potential zones, but due to the certain limitations of each odel, it is difficult to point out the groundwater potential zones using a single technique. Therefore, this present research study intends to integrate remote sensing and a geophysical approach to identify the groundwater potentiality in Karak region, Khyber Pakhtunkhwa, Pakistan. A weighted overlay analysis (Multi-influence-factor) approach has been carried out using seven thematic layers, namely: geology, rainfall, lineament density, slope, fracture density, land use, land cover, and soil type. It is interpreted that the southern portion of the Karak region is comprised of moderate and poor potential zones, the northeast is composed of high potentiality, and the northwest region is comprised of moderate to high potential. Vertical electrical sounding (VES) ID geophysical has been conducted at three different locations to support the Geospatial data that helps in the precise demarcation of groundwater potential zones.

The interpretation of geospatial and resistivity data reveals that both data sets have similar findings, i.e., at VES point-01, the water level is interpreted at 30 meters, while the same zone is considered a high potential zone by the MIF model; the water depth at VES point-02 is recognized at 170 meters, while a poor zone is marked by the MIF; and at VES point-03, the water surface is found at a depth of 137 meters, while the same zone appeared moderate to poor by the MIF model. The aforementioned interpretation is validated with the well data that has been collected from a local perspective and that depicts the 85 percent accuracy of both data sets. It is concluded that the integration of geospatial and ground geophysical approaches is an efficient way to delineate the groundwater potential zones.

Keywords: Vertical Electrical Sounding (VES); Multi-Influence-Factor (MIF); rainfall; lineament density; fracture density; Groundwater Potential Zones

Mapping evapotranspiration using METRIC model over semi-arid region of D. I. Khan, Pakistan

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Mapping evapotranspiration (ET) is critical for hydrological modelling, efficient agricultural water management, runoff estimation, crop water requirement, and sustainable water budgeting under semi-arid conditions. ET can be measured through in-situ methods i.e., Pan evaporation, Eddy covariance, lysimeter, and Bowen ratio although these approaches are not capable to represent large geographical regions. Therefore, remotely sensed satellite imagery can thus give ET at large spatiotemporal scales. Remote sensing-based approaches are useful in regions like Pakistan, where ground-based ET data is scarce. In this regard, the main objective of this research is to model ET for semi-arid region in Pakistan using METRIC (Mapping Evapotranspiration with Internalized Calibration) model and Landsat 8 OLI/TIRS satellite data from 2013 to 2016. Ground-based pan evaporation data was provided by the National Agromet Centre Islamabad. This in-situ measured ET was then used for the validation of ET estimates through METRIC model. The results show that open water and green vegetation have high evapotranspiration rates whereas dry soil, barren ground, and residential areas had the lowest ET. The modelled ET shows a very good correlation with ground-based measured data in terms of Pearson's correlation coefficient (0.87) with a very slight deviation in terms of RMSD (Root Means Square Difference) exhibiting value = 0.02. This research work demonstrates that the METRIC model has a significant potential for calculating spatio-temporal ET over large heterogeneous regions having less ground-based weather data.

Keywords: Evapotranspiration; METRIC; Landsat 8 OLI; Surface Energy balance

Assessment of Flood hit croplands and their rehabilitation status: A remote sensing-based analysis of floods – 2022

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Pakistan is one of the top-listed countries regarding vulnerability to climate change impacts. This has been significantly witnessed in the form of heatwave in March-May, 2022 followed by the intense rainy season causing above-average rains and flooding in most parts of the country. The southwestern parts of Punjab province and the Sindh province of Pakistan have suffered huge economic and life-loss due to super floods of 2022 induced by about four times the average annual rainfall. It has been estimated through the flood inundation maps developed by the Agricultural Remote Sensing Lab of NCGSA that around 300,000 ha and 350,000 ha of croplands were affected by floods in D.G. Khan and Rajanpur districts, respectively; while the massive damage of about 3.82 million-ha croplands was done in Sindh province. While the areas of south Punjab have mostly receded due to topographical advantage, several low-lying areas in Sindh are still facing the standing water or water-logged conditions. Even the receded areas may not be having conditions fully normal for the agriculture. A remote sensing based analysis was conducted to investigate the pre and post-flood conditions by considering different parameters, imperative for the favorable agricultural environment. The multiple factors studied include the water bodies maps indicating the areas still under water about four months after the floods, soil moisture conditions, soil salinity, etc. The maps developed for these indicators helped understanding the agricultural constraints faced by the farmers at the onset of the ongoing Rabi season.

Keywords: Floods-2022; Agriculture; Remote sensing; Soil moisture; Salinity; Topography

The CubeSats: small satellites for big ideas

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CubeSats are miniaturized satellites with size 10x10x10 cm3 that are primarily designed for educational and technology demonstration purposes as they allow student to design, build, and launch their own small satellites into orbit. Around the world, many countries are working for the promotion and development of these satellites as it is low cost alternate to bigger satellites and provide ample experience. The significance of CubeSats in education lies in their ability to provide hands-on learning opportunities for students in a variety of STEM (Science, Technology, Engineering, and Mathematics) fields. In addition, CubeSats development is a multidisciplinary approach which provide real-world experience with low cost.

In Pakistan, development of educational satellites was launched through CubeSat development Program and the first ever cubesat of Pakistan named ICUBE-1 was launched by Institute of Space Technology in 2013. Small Satellite Technology and Research Lab (SSTRL) is the only lab in Pakistan working for the development of small satellites for academic and research purposes. It is developing a 3U CubeSat, ICUBE-N, National CubeSat of Pakistan. The lab is also encouraging the active involvement of students in the development of satellites.

Keywords: CubeSats; ICUBE-N

Mineral deposits evaluation to assess rare metals availability for their use in photovoltaic solar cells

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Sunlight is one of the greatest source of current and future energy resources of the world. Depletion of non-renewable commodities including fossil fuels, nuclear fuel and up to some extent water has placed a greater stress on the production of electricity from renewable sunlight. The World Bank's Global Tracking Framework calculated that 24816.4 terawatt hours of electricity were generated in 2016 with 1.06 billion people continuing to live without electricity. Worldwide dependency on fossil fuel generated electricity is rapidly declining due to strict environmental policies, according to the International Energy Agency electricity production from renewable resources will be increased by 50% between 2019 and 2024 owing to its massive and widespread availability. To affirm inexhaustible solar generated electricity over 3000 US billion dollars are expected to be invested on solar power generation technologies up to 2040 (BNEF New Energy Outlook 2017). The rare metals such as cadmium, indium, gallium, selenium, germanium and tellurium are the important mineral commodities used in current photovoltaic cells technologies. These mineral commodities are recovered as by-product from the zinc-lead-copper, bauxite and coal/graphite deposits. Global demand of thin-filmed photovoltaic cells is increasing due to their flexible usage in homes, agriculture, highways/streets lights, traffic lights, hot water geysers, solar power parks, highly sophisticated equipment, cars, satellites, ships, spacecrafts, trains etc.

Pakistan has such a geotectonic setup where there is a greater potential for occurrence of the zinc-lead-copper, bauxite and coal/graphite deposits which could be investigated for the recovery of rare metals for their use in photovoltaic cells. Therefore, the main focus of the current research is to explore the rare metals cadmium, germanium, indium, gallium, selenium and tellurium in their host deposits such as zinc–lead- copper, bauxite and coal/graphite deposits of Pakistan. These deposits are mined for their major components in Pakistan, however, the occurrence and separation of these rare metals during the metallurgical processes are not given any importance to be recovered. Consequently, no exploration and extraction of these rare metals have been carried out so far in Pakistan. This research on one hand will be helpful in value addition of already occurring zinc, lead, copper, bauxite and coal/graphite deposits of Pakistan but on other hand it also brings Pakistan among the countries producing different types of commodities for preparation of photovoltaic cells.

Keywords: Photovoltaic cells; bauxite; coal; lead; Zinc

Regional scale risk assessment for landslides and debris flows (mass-wasting) in Hindukush mountain Ranges, Northern Pakistan

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Landslides and debris flows are recurring and damaging natural hazards in mountainous terrains, leading to severe environmental and economic losses and casualties. Vulnerability and risk assessments are essential for hazard mitigation, land use and developmental planning. However, they are often rarely available in developing countries. Given the topographic, climatic and environmental settings, landslides and debris flows have severely impacted communities, infrastructure and socio-economic conditions in northern Pakistan. In this study, a methodology is developed and applied using freely available geospatial tools and field-based data for one of the most prone areas for mass wasting in the Hindukush mountain ranges of northern Pakistan. These techniques are applied individually for landslides and debris flows. Very high-resolution satellite images are used to develop the inventory for landslides and debris flows and their spectral characteristics are utilized to compute the causative factors for landslides and debris flows. A bivariate model is used to generate the landslide susceptibility map. The hazard index map for landslides is computed by integrating the susceptibility map with the triggering indicator, additionally, the analytical hierarchy process is applied for hazard assessment of debris flows. The freely available remote sensing and detailed field data are used to create a set of indicators for the element at risk. Element at-risk data includes the typological data of the building footprints, roads, population, and land cover. Finally, a spatial multi-criteria evaluation technique is applied to assess the element's vulnerability at-risk data. Furthermore, semi-quantitative techniques are applied for the risk assessment, separately, for landslides and debris flows. These risk maps are classified into five categories: very low, low, moderate, high, and very high. The generated risk index maps shall be helpful in highlighting the risk hotspots and risk reduction strategies.

Keywords: Mass-wasting; Remote-sensing; Hazard; Vulnerability; Risk

Mapping of economically potential mineral zone using aster image in the Northwest Mohmand district, Pakistan

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This study presents an integrated approach to mapping carbonate minerals in the remote and difficult-to-access regions of Northwest Mohmand District, Pakistan. A combination of newly developed remote sensing techniques, including the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Image. The X-ray diffraction (XRD) and petrographic analysis were used to validate the results with the classified ASTER image. The ASTER image was first acquired and pre-processed using a range of techniques such as iterative adaptive re-weighted regression (IARR), principal component analysis (PCA), and minimum noise fraction (MNF) were applied to the image. The results of the obtained classified image were then compared with the mineralogical analysis of the collected rock samples through XRD and petrographic analysis, which confirmed the presence of high concentrations of dolomite and calcite, indicating the presence of carbonate deposits. The integration of these techniques demonstrates that remote sensing can be an effective tool for identifying and mapping mineralized zones in remote areas.

Keywords: Potential Mineral Zone; PCA; IARR; XRD

Mineralogy and Geochemistry of coal mines from Akkakhel, Akhorwal, and Sheikhan, KP, Pakistan

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The concentration of major elements and minerals in the coal deposits of Akkakhel, Akhorwal, and Sheikhan areas of Khyber Pakhtunkhwa, Pakistan have been investigated during the present study. For this purpose, six coal mines (two from each study area) were sampled. Elemental and mineral analyses were carried out using Atomic Absorption Spectrophotometer (AAS) and Scanning Electron Microscope (SEM).

The results showed that magnesium (Mg), calcium (Ca), potassium (K), aluminium (Al), silicon (Si), iron (Fe), sodium (Na) and sulfur (S) were relatively higher than the world's coal and upper continental crust. The higher concentrations and mode of occurrence of these elements are attributed to the spinel group minerals, sulfides, carbonates, and clay minerals which are common in all the studied coal deposits. These mineral phases have highly affected the quality of studied coal deposits. The froth floatation technique was used to remove the deleterious mineral phases and the studied coal was up-graded to greater extent. Further, the sulfur has been reduced to considerable level that will contribute in reduction of Sox emission to the atmosphere and a significant reduction in ash as combustion residue. The results obtained during this study will be useful for the industries such as energy, power, space technology, and cement manufacturing.

Keywords: Coalmine; Critical elements; Froth flotation; Kohat; SEM-EDX

Water clogging in arid urban areas, causes, solutions and opportunities for sustainable utilization

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Watertable rise (WTR), also known as water clogging, is a serious phenomenon observed in a number of urban areas around the world. It has imposed environmental threats and put public health under risk. WTR endangers the stability and challenges the establishment of engineering structures. WTR occurs in many arid areas lacking stormwater infrastructure several areas in Muscat, Oman where shallow water has appeared in excavations or at low-lying areas. In this research, we have utilized hydrochemical, isotopic and biological analyses to understand the causes of WTR in Muscat. The analyzed samples were collected from groundwater, surface water, sewage system and public network. The chemical analysis of water samples reveals elevated concentration of Ca, Mg, SO_4 and Cl ions resulting from carbonate and evaporitic dissolution. This dissolution caused a regional and natural increase of salinity in the area. However, local pockets of low salinity are found aligned with Public Network (PN) infrastructure, and suggest leak from PN and therefore dilution. Biological analysis shows limited presence of E. Coli encountered only in surface water which eliminates the possibility of septic tanks leak. Water classification based on deuterium and oxygene18 isotopes analysis shows three groups of water: 1- depleted groundwater recharged from prolonged heavy showers and does not interact with public network. 2- Water with isotopic signature clustering around zero suggests mixing with public network, and 3- isotopically enriched water subject to evaporation and is located either on ground surface or at shallower depths. High resolution long-term piezometric records have shown groundwater level fluctuations in response to precipitation and climatic variations. These records along with the isotopic, biological and chemical analyses indicate that WTR is aggravated by localized leak from PN while it is a natural regional phenomenon induced by urbanization. Proper planning that involves better coordination between authorities for future urban developments will tackle urbanization induced WTR. Recommended solutions to alleviate the problem include: digging temporary trenches, improve the public water network infrastructure, monitoring and testing, design and install stormwater drainage, use shallow water for different purposes (e.g. recreational areas, construction, irrigation of gardens etc).

Keywords: Ubanization, Cyclones, Water table rise, Oman, Groundwater

Debris flow geohazard assessment: A Malaysian case study

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Debris flow is a natural disaster occurred during raining season especially during monsoon in Malaysia. This natural phenomena is given extra attention nowadays because it is a natural event that causes the flow of large volumes of sand, soil, cobbles and gravel at high velocity downhill that threatens human life and property. When it happens, debris flow is not only a threat to people and property, but it also destroys ecology and the environment. The frequency of debris flow events in Malaysia is relatively low but this event has a very large geodisaster impact on the community. The debris flow is classed into three components or zones, namely the source zone, the transport zone and the deposition zone which depends on the slope angle of the bed of the flow. This paper presents the case study in debris flow assessment applied in Malaysia.

Keywords: Debris flow; Geohazards; Malayesia

Geosciences through the eye of space sciences

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Given the exponential progress in the tools and data from space sciences, the research and applications of geosciences have greatly expanded with effective, efficient, local to regional scale overview and accuracy of the outcomes. The applications of space sciences in natural hazards assessment, mapping and characterization of the geological units, forest and water resource dynamics have significantly assisted in developing and implementing policy guidelines for sustainable development. The "GIS & Space Applications in Geosciences (G-SAG)" laboratory, affiliated with the National Centre of GIS and Space Applications (NCGSA) and established at the NCEG, aims to effectively utilize various data and techniques of space sciences and field information for the fostering scientific research and capacity buildings in the lab themes of geohazards, geological applications, water and forest resources. In the multi-hazard prone northern Pakistan, advanced space and air-borne remote sensing data are utilized to assess and evaluate the landslides and earthquake-induced hazard, vulnerability and risk assessments, to contribute to the disaster risk reduction. The space-borne multi and hyperspectral satellite images, spectral analysis and image interpretation techniques are employed for the seamless mapping of lithological units and demarcation and characterization of the mineral zones to assist in mineral exploration. The temporal satellite images and secondary data are applied to characterize the water and forest resources to evaluate the trends and assist in their categorization and sustainable utilization. Sites are demarcated for the forestation of the various tree species considering the suitable climate, topography, environment and other conditions. Capacity building of the relevant officials and researchers is a significant element of the lab, and therefore a series of training workshops and awareness seminars are organized. Moreover, collaboration is established with the relevant government and non-government organizations to assist in the activities related to the lab themes.

Keywords: Geosciences; Space Sciences; Geohazard; Geological mapping; Water, Forest

Utilization of remote sensing techniques for lithological mapping and rock identification: a case study from Nizampur, Khyber Pakhtunkhwa, Pakistan

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The remote sensing satellite data plays a vital role in lithological mapping and rock identification studies. The recent up-gradation of these multi-spectral RS satellite systems provides potentially cost-effective and less time-consuming opportunities for scientists to better monitor surface dynamics. The current study demonstrates the utilization of modernized remote sensing techniques that will help map various lithological formations/rock bodies in the Nizampur area, eastern Kohat, Khyber Pakhtunkhwa, Pakistan. The selected image transformation techniques, such as Principle Component Analysis (PCA), Maximum Noise Fraction (MNF), and Band Ratio (BR) technique, were employed on Landsat-8 data for that purpose. The resultant RGB color-composite map, such as PCA (R: PC1, G: PC3, B: PC4) and MNF (R: MNFB1, G: MNFB2, B: MNFB3), demonstrates the distribution of the stratigraphic formation based on the spectral profile of target bodies. The Band Ratio (BR) color composite (R: BR3/2, G: BR5/1, B: BR7/2) discriminates and characterizes various rock bodies and their surface dynamics in the study area. The image processing techniques, along with the spectral reflectance curves of target material on the derived image, helped provide comprehensive information on various lithological features and their mapping. Results show strong agreement with the previous geological map of the study area. The study provides state-of-the-art RS methods and basic knowledge, which are of great help to the geologist and exploration communities.

Keywords: Remote Sensing; lithological mapping; Mineral Identification; multi-spectral RS satellite

Using hyperspectral imagery to map hydrothermal alteration mineralogy over the epithermal system of the Yerington district (USA)

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This study examines spectrally active alteration minerals associated with various hydrothermal alteration events, some of which are related to mineralisation while others are not. To identify and visualize muscovite-pyrophyllite intergrowth, the study utilizes high spatial resolution airborne and laboratory-based hyperspectral images in the shortwave infrared (SWIR) over the Buckskin Range, the volcanic-hosted lithocap portion of the Yerington porphyry district in Nevada, USA.

Hydrothermal alteration mineralogy is mapped at the laboratory (26 μm), and airborne (1 m) scales using spectral wavelength maps in different SWIR ranges. The Al-OH absorption feature's wavelength position variability characterises outward zoning from alunite ± pyrophyllite to muscovite in the airborne spectral data. To differentiate zones of pyrophyllite predominance over alunite within the inner domain, the 1650–1850 nm wavelength range is used. The hydrothermal alteration mineralogy is characterised by alunite, pyrophyllite, muscovite, dickite, chlorite, topaz, and zunyite, which are improved by the laboratory data. A novel spectral index, the pyrophyllite-muscovite index (PMI), is developed to address the textural relationship of muscovite replacing pyrophyllite. Two aspects are considered in characterising intergrowths of pyrophyllite and muscovite at the laboratory scale: (1) the definition of pervasive versus veinlet-controlled textures and (2) a subtle shift detection in the wavelength position of the Al-OH absorption feature of muscovite from 2189 to 2195 nm. The muscovite replacement of pyrophyllite can be identified by combining spatial patterns with the textural relationship of the pyrophyllite-muscovite association. The late muscovite replacement of pyrophyllite indicates advanced argillic alteration due to intense acid leaching followed by late near-neutral pH magmatic-hydrothermal fluids that add K+ and potentially other alkali elements and metals in the epithermal environment. This study documents the hydrothermal muscovite-pyrophyllite intergrowth relationship. It contributes to a better understanding of the lithocap epithermal system and an improved assessment of its exploration potential for Au, Ag, and Cu mineralisation.

Keywords: Hydrothermal alteration; hyperspectral images; Yerington porphyry

Assessment of landslide hazard, vulnerability, and risk in the data-poor region of Eastern Hindu Kush ranges

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Landslides are common geological hazards in mountainous terrain and have significant impacts on urbanization and the environment. The Upper Chitral valley of northern Pakistan is characterized by high-relief topography and active tectonics, with favorable conditions for landslides and debris flow. The aim of current research work is to assess the landslide hazard, vulnerability, and risk assessment in the Hindu Kush ranges using limited data. A comprehensive landslide inventory was developed through on-screen digitization and field observations and subsequently correlated with causative factors to develop a landslide susceptibility index (LSI). A landslide susceptibility map was integrated with trigging factors (Rainfall and PGA) to the landslide hazard index (LHI). The vulnerability assessment was conducted using a semi-quantitative multi-criterion evaluation (MCE) approach. The testing procedure of risk is based on the index system and consists of three stages. In step 1, the physical, environmental, and social vulnerability indexes were determined using direct and pairwise comparison matrices. In step 2, the most vulnerable zones were analyzed by integrating all vulnerability indexes. In step 3, landslide vulnerability and hazard index were integrated to develop a landslide risk index map. The risk map showed that a significant portion of the area (37.25%) had very low risk, while the low, moderate, high, and very high-risk zones comprised 62.22%, 0.37%, 0.11%, and 0.05% of the area, respectively. The developed landslide risk map can provide valuable assistance in effective landslide mitigation and land use planning.

Keywords: Hindu Kush; Landslides; Susceptibility; Vulnerability; Risk

Comparison of multispectral satellite sensors for surface lithological characterization, south of Kala-Chitta Ranges, Pakistan

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In recent years, advancement in remote sensing technology and methods has significant potential for distinguishing surface materials and producing effective lithological maps. In this study, the capabilities of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is compared with WorldView-3 (WV3) data for lithological mapping. For this purpose, southern part of the Kala Chitta Ranges is selected for which well published surface geological maps were already available. The area is characterized by complex lithological units including carbonates, sandstones and shales. The multispectral ASTER (4-VNIR, 15m and 6-SWIR, 30m) data acquired in (2007) together with commercially available WV3 (8-VNIR, 1.24m and 8-SWIR, 3.7m) data acquired in (2017) were processed and analyzed. Various image processing techniques including band rationing, principal component analysis (PCA) and spectral angle mapping (SAM) were used and abilities of both the sensors were evaluated for identifying different lithological units and geological formations. The results show that WV3 data, due to its higher spatial resolution and a wider spectral range can differentiate between different lithologies more accurately compared to ASTER data. The WV3 data has the ability to identify subtle differences in the spectral response of different lithological units that are not detectable by ASTER sensor. Moreover, the accuracy results of the lithological maps produced from VW3 and ASTER data were assessed and validated by comparing them with the existing maps and field data points. The accuracy assessment shows that the overall accuracy of WV3 is 20% higher than that of ASTER results.

Keywords: WorldView-3 (WV-3); ASTER

Estimation of remotely sensed spatio-temporal evapotranspiration using atmospheric land exchange inverse model: a comparative analysis of Skardu and Tando Jam, Pakistan

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Understanding regional scale hydrology and spatio-temporal changes in various components of the climate system involves mapping variability in Evapotranspiration (ET) on both temporal and spatial scales. In this connection, the current research aims to assess the spatio-temporal variability and distribution of ET utilizing a two source energy balancing approach on remotely sensed imagery. In order to accomplish this, the Atmosphere-Land Exchange Inverse (ALEXI) Model, a two-source energy balance model, was utilized to on Landsat-8 imagery. The two-source approach, for calculating energy balance, have the capacity to distinguish between soil and vegetation and, hence, separate fluxes are estimated. In this study, ALEXI was used to predict the latent heat flux using the following variables: LAI (Leaf Area Index), Rn (net radiation), LST (Land Surface Temperature), and albedo.

The focus was given to compare the mentioned approach under varying climatic conditions of Pakistan. For this purpose, two different regions have been selected, namely Skardu (cold snowy with dry and hot summer) and Tando Jam (desert hot climate with dry winters). The model showed satisfactory results under both climatic conditions with correlation coefficient (r) of 0.83 and 0.81 at Tando Jam and Skardu, respectively. The present study reveals an increasing ET trend at Skardu from the year 2013 towards 2020 for both modelled and station ET. At Tando Jam region, a slightly decreasing trend was exhibited for both modelled and station ET. Overall, the two source energy balance of ALEXI proved to be applicable under these two climatic conditions of Pakistan. The approach should be extended to other regions of the country and must be test with other sensors as well.

Keywords: LAI; Net Radiation; Energy Balance; Climatic Conditions; Validation

Tracking slow-moving landslides with InSAR in Hindukush

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The slow-moving landslides can lead to catastrophic failures. Monitoring, assessing, and mapping of such landslides in the rugged mountainous terrain of Hindukush is challenging, costly and time-consuming. Recently, satellite-based synthetic aperture radar interferometry (InSAR) has been used to estimate millimeter-scale detection of ground surface deformation which can provide key information for the detection of landslide-susceptible areas. We have used the sentinel-1 data in two sets (Ascending and Descending) in time series to assess slow-moving landslides in the Chitral area of the Hindukush. Our study has led to the discovery of several slow-moving landslides in the region with an average velocity of 25 - 80 mm/yr, reflecting a worrying situation for Karimabad, Reshun and Breshgram villages. The results have also been compared with possible causative factors such as geology, seismicity, precipitation, temperature, which reveals that the area is experiencing a variated deformation due to the combination of several causative factors acting together, predominantly, topography/steep slopes, freezing and thawing of snow and seismic events.

***Keywords**:* Slow-moving landslides, Chitral, Hindukush, hazard, InSAR

Beware: Better early warning and responsible effect handling

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The prediction of the timing and extent of natural hazards, as well as the impacts they generate (which turn such a hazard into a disaster) is a field of rising importance, but with many unanswered questions. As a society we struggle to take account of how rapidly risks are changing in a warming climate, and we often fail to forecast compounding impact of different hazards. We haven't solved the problem yet on how to include and model the increasing complexity and multi-sectorial nature of the consequences, with cascading impacts through sectors and regions, including impacts aggravated by misguided human responses.

The fundamental problem is that the present scientific basis for early warning systems and (climate) event attribution is relatively weak. This varies per hazard and can be rooted in lack of data or data uncertainty, but also in insufficient understanding of the interacting and cascading underlying (physical) processes. We can build operational Early Warning Systems, as is presently being done at the Dutch Meteorological Service (KNMI) and a few other national weather services, but the complex interdisciplinary scientific questions, although fundamental for a reliable functioning, have hardly been addressed so far. Furthermore, the scientific challenge is exponentially amplified once compound events are considered, or early warning concepts are applied in the Global South.

The innovative science therefore hinges on two major aspects. The first aspect is addressing the deeper scientific questions that relate to our understanding of hazardous processes and establishing relations and models that form the fundament for reliable prediction. The second aspect is to develop techniques and approaches to incorporate climate considerations into decision-making processes and in the design of interventions such as early warning systems and anticipatory actions.

It will advance our ability for early warning and early action across time and spatial scales, specifically related to the influence of humans on climate related hazards. The gaps in our understanding of these triggering events and their cascading effects provide the basis for our challenge to improve our knowledge on the current impact of climatic extremes, to anticipate future weather, and to connect such changing hazards to changing impacts. This insight then allows us to evaluate risk management options on short and longer timescales, extending from early warning to systematic changes, especially in the face of limits to adaptation.

Keywords: KNMI; Hazards

Occurrence and value addition of barite from Lasbela region, Balochistan, Pakistan

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Barite mineral is an important economic commodity in the global market because of its varied uses and applications. Nowadays, Pakistan is also emerging on the sky of barite producing countries and its world ranking is being improved with every expanding year. Ample consumption of barite mineral is reported in the local market as well as in the global market. The economics and consumption of barite can be enhanced by opting for proper mining and processing techniques in the perspective of end users.

The south eastern part of Lasbela District, Balochistan, Pakistan contains a number of medium to small size barite deposits. These are stratabound and stratiform types of deposits; mainly confined in the Ferozabad Group of Jurassic age. In the Lasbela area, barite is mostly mined by the open pit method. Depending upon the nature of barite deposit, mining and excavation is done by drilling, blasting or with the help of a shovel. Further processing is done based on the demand of consumer. Hand sorting, crushing and separation of low specific gravity materials like gypsum and clay using classifier are done in processing units before supply to the market. Impurities like quartz, sphalerite, galena, pyrite or host rock traces are removed by gravity separation. For the use in drilling mud and as filler in different industries mineral beneficiation is done by controlling particle size and shape as well as the removal of innocuous minerals for use as aggregates. Advance value addition of barite mineral is accomplished by monitoring its strength, concentration of water soluble chemical constituents, iron and other toxic elements.

Keywords: Barite; Value addition Lasbela

Establishment of Space Education Research Lab (SERL): A novel initiative for promoting space science, technology and its applications in Pakistan

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The Space Education Research Lab (SERL) a specialized research lab housed at the Institute of Space Technology (IST) in Islamabad, Pakistan, is a constituent Lab of the National Center of GIS & Space Applications. Developing nations face significant hurdles in achieving the UN SDGs through space technology due to the lack of specialized degree programs, human resources, academic materials, and career clarity in this field. To overcome these obstacles, need assessments were conducted for all age groups, and interactive teaching methodologies needed to be developed. SERL's purpose is to develop specialized human resources in the field of space science, and technology and its Applications for the socio-economic growth of Pakistan through increased awareness and education. The lab has two application domains: Space Awareness and Outreach, and Education and Training. Under the Space Awareness and Outreach domain, SERL conducts several activities, including World Space Week celebrations, Space Summer School, Dr. Abdus Salam Space Contest, and Space Awareness Visits and Destination Space Schools across Pakistan. These initiatives aim to increase awareness of space-related activities among the general public and students. In the Education and Training domain, the lab provides specialized training, and workshops targeting students, teachers, and professionals in the field of space science and technology. The lab also develops space-related books for children, websites, and applications for space enthusiasts. The outputs of SERL include the development of specialized human resources in space science and technology, creation of effective knowledge-based awareness, and opening new doors for innovation and application development leading to a better and sustainable lifestyle for the general public. Additionally, SERL inspires young aspirants to join the profession of space science and technology, creating a passionate, dedicated, and talented workforce. SERL is a pioneering initiative in Pakistan to increase awareness and education in the field of space science and technology, and an essential step towards developing specialized human resources for the socio-economic growth of the country. The lab strives to engage the general public, students, and professionals in the field of space science, technology, and its applications, creating a unified effort at the national level.

Keywords: Space Education Research Lab (SERL)

The establishment & innovative contributions of the Global Navigation Satellite System (GNSS) Research Lab

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The Global Navigation Satellite System (GNSS) Research Lab, a component of National Center of GIS and Space Applications (NCGSA), a project of Higher Education Commission (HEC) of Pakistan, is a state-of-the-art research facility at Institute of Space Technology, Islamabad, is equipped with cutting-edge GNSS receivers and equipment. The lab is committed to advancing the field of GNSS through rigorous research in various domains, including constellation design, NAV- COM integration, GNSS Signal & integrity monitoring , space weather, natural hazard monitoring, earthquake monitoring, ionosphere monitoring, and volcanic eruption monitoring. One of the key achievements of the GNSS Lab has been the development of a regional navigation satellite system for Pakistan, which has the potential to revolutionize navigation and positioning services in the country. The lab has also made significant contributions to the study of natural hazards and geological events using GNSS signals, which can help to improve disaster response and management efforts. In addition, the GNSS Lab has developed software GNSS receivers for various applications, as well as advanced algorithms for signal security and interference detection and mitigation. These developments have the potential to improve the accuracy, reliability, and security of GNSS services in various sectors, including transportation, telecommunications, and emergency response. Moreover, the GNSS Lab is actively engaged in education and outreach activities, including seminars, workshops, and training sessions, to promote the use of GNSS technology and provide valuable insights to professionals, researchers, and students. By fostering collaborations and promoting innovation in this field, the GNSS Lab is playing a crucial role in advancing the state-of-the-art in GNSS technology and its applications. In conclusion, the GNSS Research Lab in NCGSA is a phenomenal research and teaching facility dedicated to advancing the field of GNSS through rigorous research, innovation, and education.

Keywords: Global Navigation Satellite System (GNSS); Space Education and Research; National Centre, National Centre of GIS and Space Applications (NCGSA)

Micro-meso structural deformation and tectonic imprints of the Hazara-Kashmir Syntaxis on Lesser Swat area, North Pakistan

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Integrated micro and meso structural investigation were carried out in the multiple deformed rocks of swat region of Northern Pakistan (North-West Himalayas). The studied samples represent the Indian plate cover sequence, deformed, and metamorphosed to medium- and high-grade during the Himalayan orogeny. Two well-developed mesoscopic deformation folds D2 and D3 are recognized in the region. The NNW-SSE trending D2 folds developed during the NNE-SSW horizontal bulk shortening followed by NNE-SSW trending D3 folds, which are developed during NNW-SSE shortening. NNE-SSE trending S2 crenulation cleavages are folded by D3 deformations both microscopically and mesoscopically, which can be clearly observed in boudinage structures and mineral stretching lineation. The recognition of NNW-SSE folds in Marghazar Gorge termed D2 and D3 both microscopically and mesoscopically postdate F1,F2, F3 and F4 structures in the Lesser Swat North Pakistan.

The petrographic studies of the samples suggests that the inclusion of muscovite and biotite in garnet porphyroblast indicate regional metamorphic conditions in swat region. Garnet, Staurolite and Calcite porphyroblasts grew before D2 deformation because the sophisticated S2 cleavage related with D2 in the matrix wraps around these porphyroblasts. The inclusion trail in garnet and staurolite are truncated by S2 cleavage in the matrix. Microscopically the main matrix foliation is well defined by, muscovite, biotite calcite, and quartz.

Keywords: Boudinage structures, porphyroblasts, foliation