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A Scrum Framework for Requirement Engineering Practices

Asma Batool, Yaser Hafeez*, Sohail Asghar, Muhammad A. Abbas
and Muhammad S. Hassan

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Abstract: Nowadays, software development industry has departed from traditional development to Agile software development. In this paper we have proposed a conceptual framework. The main emphasis in this framework is to make the requirement engineering process more effective and add to the suppleness of it. The research method we have used in this research is case studies, expert reviews from the software industry, existing published reports and articles. The proposed framework has resulted in improving the previous related work. This framework provides guidelines and an easy to adapt approach for the software development teams.

Keywords: Requirement engineering, traditional requirement engineering, agile, scrum

1. INTRODUCTION

Requirements are the desired specification functions that illustrate what will be the software product [1]. Traditional requirement engineering is based upon some key factors, and these steps include identification, analysis, documentation, validity and management of requirements for the system to be developed [2]. In requirement elicitation activity, an analyst gathers requirements along with any other information from the stakeholders, and organizes them to develop the software requirement specification document [3]. Raw requirements are collected from the stakeholders. Various techniques are used to collect the requirements, like system prototyping, model-driven techniques and cognitive techniques [2]. Requirements prioritization and traceability issues are resolved in the requirement analysis. Requirements are organized in some consistent and accessible way in requirement specification. After documentation of the requirements, there is a need to verify the requirements in the requirement verification phase. Requirements are verified through writing test cases and checklists.

Changes in requirements are tackled by requirement management. Each anticipated change needs reviewing and estimation before it is accepted by the change control board [4]. Agile methods belong to a family of software development processes. It became popular during the last few years [5]. Agile framework emphasizes on two main principles, the first one is active communication between team and users whereas the second principle deals with iterative, incremental, continuous delivery and flexible approach to development. Agile RE is an approach different from the traditional RE because Agile RE focuses on iterative approach as requirements engineering activities like elicitation; negotiation, documentation are carried out in small development cycles [6]. Both the approaches have similar goals, the main difference is that the traditional RE depends more on documentation but Agile RE has reduced concentration on documentation and keeps focus on face to face communication with customers. RE involves the customers only in early stages of the development process but Agile RE involves the customers throughout the process [7]. Agile requirement engineering decreases the communication gaps
between customers and developers. Consequently, it can easily manage the change in requirements at any stage of the software development life cycle. Requirement gathered at early stage creates problems during later stages because requirements evolve throughout the development process due to customer needs. So there is a need for an iterative process that may communicate with the customer at any stage. Continuous change in process is a salient feature of agile as the software being developed consists of small releases and change is essential to agile methods [8]. Agile processes replace the other old processes to speed up the development process and cope with the changing requirements of different organizations [9]. Different methods of agile are very helpful in the software development that focuses on abilities, communication, roles and relationships between customers and developers [10]. A scrum is a well-known agile method that focuses on the project management [11]. It has a unique framework that consists of best practices which have been successfully applied in software development process [12]. Scrum is quite a favorable agile approach when applied to small and medium projects, rather than a full process or methodology; its framework does not provide the detailed description of the project because the team involved in the project better knows how to tackle every problem [10]. A scrum is a development method in which software is delivered in increments called sprints [13]. It starts with the vision and rises with core requirements and set their priorities in the form of the product backlog. The team plans the requirements in the form of sprint backlog. Each development cycle completes in sprints that involves the designer, developer, tester complete functionality to complete an increment in functionality. The team demonstrates the completed functionalities to stakeholders to get their trust in the sprint review meeting and sprint retrospective. The scrum process consists of three artifacts i.e. Product backlogs, sprint backlogs and burn-down charts. Backlogs are about the customer requirements and daily burn down charts demonstrates the collective work left behind. [14]. It became popular because its an iterative, flexible and reliable process in which all development phases are completed in shorter sprints and change is easy to manage [15].

2. RELATED WORK

Many researchers have presented the difference between traditional requirement engineering and agile requirement engineering [16]. Requirement engineering is a multidisciplinary activity that consists of multiple techniques and tools which is a very important phase in the software development life cycle [2].

The traditional RE process is a very time consuming process so modern software industry demands an iterative and speedy process [5]. Lucy et al has also mentioned some recommendations to solve the problems related to documentation and critical requirements because functional and non-functional requirements are difficult to handle in the requirement document [6].

Paetsch et al [7] have listed some important features of RE process and have critically examined their applicability in agile methods [8]. Michael Coram et al evaluated the effects of agile methods in project management, people involved in the project and their applicability. Agile Methods recommended a realistic approach to overcome the changes. Agile methods are helpful when applied under the right situation [17].

Sen and Hemachandran [3] presented an Agent Based Goal Elicitation (ATABGE) system that consists of agile approaches. The system involves the agents and stakeholders for decomposing and refining the high level goals into low level goals [3]. Liu Jun et al presents the comparison of Agile RE and Traditional RE and addresses the issues related to the Traditional RE and concluded that Agile RE practices are best for the modest-sized developments [18].

In Veerapaneni Esther Jyothi et al proposed a collaborative and innovative framework for the solution of difficulties faced by developers in agile software development [19]. In another study, Emam Hossain et al. Identifies the risks related with the scrum used at GSD by conducting a systematic literature review of primary papers. It captures some kind of risks and presents their solutions in the form of a conceptual framework [20]. A framework is introduced by Sven Overhage et al which is based on extended Technology Acceptance Model (TAM). It presents the developer’s approval of scrum and
sets up guidelines to understand the methodologies [21].

Rohit Ramanujam et al describes the study about the multi vendor challenging situations and propose a collaborative framework for agile scrum development. Subject Matter Expert (SME) plays a vital role in producing successful and collaborative environment. Each team must have its own scrum master who is responsible for removing the barriers [22].

Shvetha Soundararajan presents the Agile Requirement Generation Model (Agile RGM) that is structured to support the agile requirement engineering process. This model helps to choose the different existing agile methods provides a successful agile requirement engineering process. Agile RGM consists of five phases, education phase, feature development, story development phase, task development phase and development phase. These five phases are combined together to support a vigorous agile requirement engineering process [23]. The Standish Group surveyed IT executive managers for their opinions and found out that why projects succeeded. The project success is based upon three major factors which are user involvement, managerial support and a clear declaration of requirements [24].

3. MATERIALS AND METHODS
As many organizations move to agile development and switching from traditional requirement engineering to agile requirement engineering because of issues and problems faced in the traditional requirement engineering. In large organization’s requirements are evolving throughout

Fig. 1. Scrum process flow with respect to roles, activities and artifacts.
the development process and due to the iterative nature of agile development. In this context, we have decided to present a framework that combines the requirement engineering and scrum practices. A scrum is a very useful and efficient agile approach that helps to make the requirement engineering process flexible. The proposed framework makes certain the efficiency and flexibility of the requirement engineering process, software development removes the issues that are faced in the traditional requirement engineering process due to changing requirements, lack of communication and feedback of customers. Our proposed research method consists of two parts. First part in Fig. 1 describes the flow of scrum activities and the second part in Fig. 2 presents the proposed requirement engineering framework with the scrum practice.

3.1 Scrum Process Flow with Respect to Roles, Activities and Artifacts

This process hierarchy in Fig. 1 describes the flow of scrum activities in the form of its Roles, Artifacts and Activities. Gray boxes on the left side in Fig. 1 are representing the roles, white boxes in the middle are showing activities and white boxes on the right side of figure are showing the artifacts of the scrum approach. The detail description of this process is given below:

The product owner is responsible to define the desired outcomes of the project and prioritize the features of the product. Regulate feature and priority in every iteration, as needed. Product owner considers the Return On Investment (ROI) and responsible for accepting or reject work results.

Scrum master represents the management of the team and ensures that team is efficient and creative. Resolves the problems and protect the team from external intervention.

Cross-functional team consists of 5-9 people including programmers, testers, and designers. The team is responsible for failure or success of the product.

Product Backlog Contains the requirements that are prioritized by the product owner. Requirements are prioritized at the start of each sprint.

Sprint Backlog consists of the requirements that are ready to develop. Each Item on the sprint backlog includes description and estimate.

![Fig. 2. Scrum requirement engineering process.](image-url)
User Story is the initial requirements in the form of story cards and index cards.

In Sprint Planning selects the items from the product backlog and creates the sprint backlog.

Sprint Review presents what has been completed during the sprint in the form of demos of new features.

Sprint Retrospective involves all the members i.e. scrum master, product owner, team and stockholders. It has occurred at the end of every Sprint after review meeting and discusses the experiences and problems faced during development.

3.2 Proposed Scrum framework

The overall structure of our proposed framework consists of 5 phases as shown in figure 2. Basically these steps show the flow of our work. Each of these steps, perform a valid functionality in the proposed framework. Each and every step is detailed below:

**Vision**: In the vision we describe what we want to do with the system.

**User stories**: User stories are the description of requirements expressed by customers that consists of sufficient information needed by the developers for the effort estimation and implementation. Product owners elicit the requirements by consulting with the stakeholders in the form of user stories. The requirements are taken on story cards. All requirements are not gathered at this stage; they are flexible and can be changed at any given stage. After gathering the requirements in the form of user stories these raw requirements enter into the first step which is planning.

**Phase 1: Planning**

Planning consists of prototype modelling, requirement prioritization and effort estimation. Prototype modelling is not a scrum activity; we integrate it into scrum to make the requirements clearer. It helps to understand the requirements in the form of user stories. With the agile point of view Product owner prioritizes the requirements and then estimates the efforts of these prioritized requirements. The input of this phase is the raw requirements and output is the preferred requirements. The product owner engages the stakeholders in every step in the planning phase.

**Phase 2: Approved & well-disposed Requirements**

After the identification of preferred requirements, these are collected in sprint backlogs. In this phase product owner and scrum masters select the team for constructing the selected requirements. Sprint backlog requirements are ready to implement in running sprints.

**Phase 3: Build**

In this phase, approved requirements are designed, coded and tested by a cross functional team. The approved requirements are designed by preparing their class diagram to make them more specific and understandable for programmers. Then these designed requirements are coded by choosing a language in which programmer can easily code them. After implementation requirements are tested. Tester applies unit tests to check the functionality and reliability of the system. A daily meeting of 15 minutes duration is arranged to check the efficiency of the team members, only product owner, scrum master and team members can discuss the status of work. The output of this phase is the working software.

**Phase 4: Testing**

In this phase, the team itself applies the system test to finally check the working software. In the system test team assure that the system is fulfilling the specified requirements and checks its overall performance by deploying software.

**Phase 5: Handover System**

The main objective of this phase is to verify the product that meets the specified requirements and assesses the response of the customers. Product owner, scrum master, team and stakeholders gather to test the deployed software. In sprint retrospective, the team demonstrates the performance of working software. Acceptance testing is done by the product owner and stakeholders. If the product meets its specified requirements and raises the level of satisfaction then the product will deliver to the stakeholders otherwise pointed issues are resolved in the planning phase in the next cycle.
4. RESULTS AND DISCUSSION

We shall consider a case study of Management Information System (MIS) of a university where we will check the effectiveness of our model by the expert opinions of the software industry.

A public sector university X has been planning to launch a Management Information System (MIS). It has recently computerized its examination process based on some off-the shelf software. The university also has a computerized library management system. The university management team decided to develop a single large MIS because the University has loaded itself with too many independent information systems.

The university has assigned the task of developing an MIS for the University to industry. This MIS system consists of 3 systems:

- The Student Information Management System (SIMS) is a system for managing the student information. It contains the record about enrolled students, their personal information, respective courses, classes and teacher schedules, absences and attendance, fees and fines, health conditions, boarding house details, communications with students and their parents.

- Examination Management System (EMS) contains the information about student exams and their results. Its features include examination schedules, no of students appearing in exams, no of students not appearing in exams because of valid reasons, available classrooms, results, student grades and scores.

- Library Management System (LMS) consists of a graphical user interface. All users can login and register through this interface. It contains the information about registered students, books regarding their particular subjects, issued books, returned books, and generate a fine list. The librarian can login, register, add category, add/ remove book, and can do add/ remove issue and return books information through the system. Our evaluation method is based on eight requirement engineering success factors. These are efficiency, flexibility, visibility, cost effective, concise documentation, adequate and constant communication, project status demonstration, responsive to change [25]. We select these factors from previous research and by conducting surveys of the software industry. These factors are very important for the effective requirement engineering process. We get the response from ten industry experts who are involved in this project.

Some of the existing scrum frameworks improved in the software development but our proposed framework has produced is the requirement engineering process. Evaluation of the proposed framework is shown in table 1; it contains the expert opinions about existing Traditional RE, proposed Scrum RE and their difference on the basis of 8 requirement engineering success factors. The results of this survey are shown in Fig 3. It is clear that the proposed Scrum RE framework performs better than existing Traditional RE process. Difference in claiming benefits of existing and proposed approach shows a reasonable improvement in

![Graphical representation of cumulative results.](image)
development Lifecycle. These mentioned success factors are necessary for the effective requirement engineering process. From the expert opinions it is clear that scrum RE is the most effective method of the requirement engineering process.

5. CONCLUSIONS

Requirement engineering is an important and difficult phase in a sense that different stakeholders have different attitude and expectations about the system and problem occurs when all requirements are elicited at an early stage because at very initial stage customer did not have an idea about the system so changes are must throughout the process. Our main emphasis behind this research is to build and evaluate a framework that can help the requirement engineers in the requirement engineering process. This framework will minimize the complexities and barriers faced during the traditional requirement engineering process. We have evaluated the proposed framework through the expert judgment opinions on the basis of eight requirement engineering success factors. This framework has established the standard guidelines for the effective requirement engineering process. In future work, we will evaluate the value and validation of our framework through more case studies to make it more effective and applicable in any kind of project.

6. REFERENCES


Earth Retention Systems Disasters: Causes and Prevention

Ammad Hassan Khan*
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Abstract: In recent years, the trends of deep excavation for basement construction in high-rise buildings are getting rapid popularity in Pakistan. However, the design and construction specifications of earth retention systems adopted for deep excavation are not yet standardized which have resulted in a number of recent disasters. This paper addresses earth retention system disasters and associated problems observed in design and construction using database of 20 recent projects located at Lahore, Pakistan. Some of these problems are unique to Pakistan, whereas several others are universal. The illustrations of such problems and the preventive measures have been described. It is emphasized that these problems can easily be avoided by adopting effective project management, quality control measures as well as by enforcing the appropriate geotechnical engineering byelaws and specifications in the projects.

Keywords: Earth retention, geotechnical engineering, project management, risk management, design, construction

1. INTRODUCTION

Basement is part of the infrastructure which is constructed below the natural soil level. Deep excavation is a prerequisite for construction of the basement. Appropriate earth retention systems are required to execute deep excavation. Earth retention systems are primarily provided for the protection of workers during deep excavation and construction. In addition, the protection of adjacent infrastructures and utilities are also key consideration for the provision of earth retention system. Numerous types of earth retention systems are available in the industry which include sheet piling, soldier beam and lagging, soil nail and shortcrete, internal bracing (i.e., soil anchors and tie backs), external bracing (i.e., struts, diagonal and rakes), secant and tangent piles, and under pinning [1]. Any particular type of system can be used depending on the soil conditions needing deep excavation. The design as well as construction of each system involves control of multiple parameters deduced from geotechnical, structural, architectural and environmental considerations [2]. The stakeholders involved in earth retention system projects include owner/client, designer, constructor/contractor and supervisor.

Lahore being capital of the Punjab province is the second largest and thickly populated city of Pakistan. Lahore city and its surroundings have been serving as major business and industrial hub in the economic growth of Pakistan. Since 2000, the real estate has been among the prime areas of investment in Lahore. For sustainable housing and commercial demands in Lahore, vertical urban development was adopted as a successful solution by the construction stakeholders. Hence, high-rise multistory buildings have been constructed. After the development of the high rise multistory infrastructures the parking space constraint has emerged as a serious hazard at different locations of the cities. Consequently, the Lahore Development Authority (LDA) has introduced byelaws to address the parking constraint particularly for the high-rise buildings by enforcing the provision of basement parking. As a result, deep excavations and earth retention systems in multi-level basements are
widespread ongoing construction activities in the city. However, many kinds of disasters have been observed in most of the recent earth retention system projects [3, 4].

The main objectives of this research were to investigate main causes of failures/disasters of earth retention systems by comparing the design and construction practices of locally adapted earth retention systems with international standards. Suitable preventive measures have also been proposed to avoid and minimize such failures in the future.

2. MATERIALS AND METHODS

The objectives of the research were achieved by adopting following methodology:

- Identifying projects in Lahore and its urban vicinity which faced partial or complete failure during design or construction of earth retention system.
- Characterization of typical soil profile of Lahore city up to 15 m and onward depth for determination of suitability of best possible earth retention system for carrying out deep excavation.
- Evaluation of best possible earth retention system for the equivalent soil profiles by comparing the design and construction methodologies adopted in these projects with international standards. This was achieved by carrying out following investigations:
  - Detailed study of the following project documents:
    - Prequalification procedure adopted by the client for technical and financial evaluation,
    - Contract and conditions of contract,
    - Bill of quantities,
    - Tendering process,
    - Project drawings and design documents.
  - Design and analysis calculations
  - Detailed evaluation of technical specifications along with byelaws provisions
  - Detailed meetings with representatives of project stakeholders
  - Interviewing different trades of human resources for the assessment of the failure attributions.
  - Detailed evaluation of following project practices and its implementation
    - Human resource management
    - Equipment and plant management
    - Procurement management
    - Financial management
  - Data analysis to determine inadequacy in design and construction of earth retention system as well as deep excavation.

3. RESULTS AND DISCUSSION

Case studies of earth retention system taken from twenty multistory commercial building projects located in Lahore city are studied. The list of the projects is tabulated in Table 1.

Table 1. List of high rise projects in Lahore city.

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Project Name</th>
<th>Sr.</th>
<th>Project Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tricon corporate center</td>
<td>11</td>
<td>Sherpao Plaza</td>
</tr>
<tr>
<td>2</td>
<td>Ahad Tower</td>
<td>12</td>
<td>Lahore City Center</td>
</tr>
<tr>
<td>3</td>
<td>Pace</td>
<td>13</td>
<td>Warid Office</td>
</tr>
<tr>
<td>4</td>
<td>Haly Tower</td>
<td>14</td>
<td>China Center</td>
</tr>
<tr>
<td>5</td>
<td>Pace Hayat</td>
<td>15</td>
<td>Alamgir Tower</td>
</tr>
<tr>
<td>6</td>
<td>DHA Mall 1</td>
<td>16</td>
<td>Boulevard Heights</td>
</tr>
<tr>
<td>7</td>
<td>Fortress Tower</td>
<td>17</td>
<td>City Tower</td>
</tr>
<tr>
<td>8</td>
<td>Mubarak Center</td>
<td>18</td>
<td>DHA Mall 2</td>
</tr>
<tr>
<td>9</td>
<td>Liberty Trade Center</td>
<td>19</td>
<td>Alfalah Tower</td>
</tr>
<tr>
<td>10</td>
<td>IT Tower</td>
<td>20</td>
<td>MCB Tower</td>
</tr>
</tbody>
</table>

Locations of the project sites in Lahore city are shown in Fig. 1.

During identification of the projects criteria was made that the projects should be those which must observe constraints of different intensity during design or construction life cycle of earth retention system. The partial design disaster of earth retention system were observed in projects serials 2, 3, 4 and 5 (Table 1). The partial construction failures of earth retention system were recorded in projects serials 6, 13, 14, 15, 16, 17, 18 and 19 (Table
1) Limited design or construction debacles were noted in rest of the earth retention system projects. The current status of the projects is that the earth retention system disasters were cope down on all projects except two i.e. Alamgir Tower and Sherpao Tower. The construction on these two towers was permanently abandoned after failure of earth retention system.

The soils subjected to deep excavation can be categorized into a typical profile based on the database of the geotechnical data obtained from the projects. The typical soil profile of Lahore city is shown in Fig. 2.

![Fig. 2. Typical soil profile in Lahore city.](image)

In such soil profiles (Figure 2), the secant piles earth retention systems are most appropriate for deep excavation [6]. All the projects listed in Table 1 also employed the secant piles earth retention system for deep excavation. Table 2 presents the steps involved in successful completion of earth retention system design and construction based on international standards and specifications [6–9].

Fig. 3 shows physically secant pile earth retention system and its components.

Fig. 4 presents the configuration of secant piles earth retention system design in term of its geotechnical design stability [6]. The soils behind the secant piles are subjected to active pressure. The soils under the toe of the secant piles embedded length is subjected to passive pressure.

During detailed investigations of technical and financial documents of each project it was observed that the standardized design and construction procedures for earth retention system was not observed. That led the failures of different intensity during the construction lifecycle of earth retention system. Figure 5 shows the glimpses of failures observed in the projects due to inadequacy in design.
Table 2. Major design & construction steps of secant piles earth retention system.

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Site Layout (Surveying)</td>
</tr>
<tr>
<td>B</td>
<td>Preliminary Geotechnical Investigation (Selection of number and depth of boreholes with non-destructive testing)</td>
</tr>
<tr>
<td>C</td>
<td>Detailed Geotechnical Investigation (Drilling of bore holes, In-situ Testing, Laboratory Testing)</td>
</tr>
<tr>
<td>D</td>
<td>Determination of Soil Type, Depth and Its Properties (Based on analysis using laboratory and in-situ test results)</td>
</tr>
<tr>
<td>E</td>
<td>Geotechnical Secant Pile Design (Pile capacity in term of skin friction and end bearing, Pile depth and interval)</td>
</tr>
<tr>
<td>F</td>
<td>Geotechnical Tie Beam Design (Number of tie beams)</td>
</tr>
<tr>
<td>G</td>
<td>Geotechnical Anchorage System Design (# of anchor rows, diameter of cable, bonded &amp; unbounded length with inclination)</td>
</tr>
<tr>
<td>H</td>
<td>Structural Design of Secant Pile (Pile diameter and reinforcement)</td>
</tr>
<tr>
<td>I</td>
<td>Structural Design of Tie Beam (Beam dimensions and reinforcement)</td>
</tr>
<tr>
<td>J</td>
<td>Drilling of Secant Piles</td>
</tr>
<tr>
<td>K</td>
<td>Preparation of Reinforcement Cage of Secant Piles (Cutting &amp; bending)</td>
</tr>
<tr>
<td>L</td>
<td>Lowering of Reinforcement Cage of Secant Piles (Through Crane)</td>
</tr>
<tr>
<td>M</td>
<td>Casting of Concrete for Secant Piles (Through Trimmy and Crane)</td>
</tr>
<tr>
<td>N</td>
<td>Top Level Tie Beam Shuttering</td>
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<tr>
<td>O</td>
<td>Top Level Tie Beam Reinforcement</td>
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<tr>
<td>P</td>
<td>Top Level Tie Beam Concrete Casting</td>
</tr>
<tr>
<td>Q</td>
<td>Deep Excavation Level I</td>
</tr>
<tr>
<td>R</td>
<td>Mid Level Tie Beam Shuttering</td>
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<td>S</td>
<td>Mid Level Tie Beam Reinforcement</td>
</tr>
<tr>
<td>T</td>
<td>Mid Level Tie Beam Concrete Casting</td>
</tr>
<tr>
<td>U</td>
<td>Mid Level Anchor Bore Hole for Bonded Length</td>
</tr>
<tr>
<td>V</td>
<td>Mid Level Anchor Installation</td>
</tr>
<tr>
<td>W</td>
<td>Mid Level Anchor Bonded Length Grouting and Clamping</td>
</tr>
<tr>
<td>X</td>
<td>Deep Excavation Level II</td>
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<tr>
<td>Y</td>
<td>Bottom Level Tie Beam Shuttering</td>
</tr>
<tr>
<td>Z</td>
<td>Bottom Level Tie Beam Reinforcement</td>
</tr>
<tr>
<td>α</td>
<td>Bottom Level Tie Beam Concrete Casting</td>
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<tr>
<td>β</td>
<td>Bottom Level Anchor Bore Hole for Bonded Length</td>
</tr>
<tr>
<td>γ</td>
<td>Bottom Level Anchor Installation</td>
</tr>
<tr>
<td>δ</td>
<td>Bottom Level Anchor Bonded Length Grouting and Clamping</td>
</tr>
<tr>
<td>ε</td>
<td>Deep Excavation Level III</td>
</tr>
</tbody>
</table>
Earth Retention Systems Disasters

Fig. 3. Components of secant pile earth retention system.

Active pressure zone depends on soil shear strength, unit weight and active earth pressure coefficient.

Passive pressure zone depends on soil shear strength, unit weight and passive earth pressure coefficient.

Fig. 4. Soil pressure zones around secant piles for external stability.
Fig. 5. Earth retention system failures due to design inadequacy.

Table 3. Comparative summary of design stages adopted in each investigated project.

<table>
<thead>
<tr>
<th>Design</th>
<th>Sr.</th>
<th>Projects Serial</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<tr>
<td>B</td>
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<td>C</td>
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<td>I</td>
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</tbody>
</table>

x (Completely Performed), - (Not Performed), * (Incomplete Performed)
In all the investigated projects preliminary geotechnical investigations was skipped (Table 3). The main reason that was probably in the minds of stakeholders in not carrying out that activity was that it was followed by detailed geotechnical investigation. The preliminary geotechnical investigations actually led to planning of scope, schedule and budget of the detailed geotechnical investigations. The absence of preliminary geotechnical investigations led to ambiguities in the methodology for the precise determination of soil types and its requisite design properties. The research has proved that the projects have not been able to achieve complete requirements of detailed geotechnical investigations without preliminary geotechnical investigation [7]. More are the frequency of these ambiguities more severely a project was affected during construction [10]. In all the projects the detailed geotechnical investigation was carried out using standard penetration test (SPT). The soil samples retrieved from the SPT split spoon samplers were collected for necessary laboratory testing [8]. The minimum requirement of the depth and number of boreholes [6] as per standard for any particular project were not met. Some projects stakeholders gave importance to the findings of geotechnical investigation (controlled risk) while others tried to skip it partially or completely (uncontrolled risk). The projects which have given importance to geotechnical investigations (controlled risk) were saved from potential failures while others who skipped it faced noticeable failures as shown in Figure 5. The design consultant is the stakeholder who took uncontrolled risk of not carrying out geotechnical investigation. Further, the local bye-laws of development authority do not discuss the role of preliminary geotechnical investigation which gives cushion to project stakeholders to skip it completely or partially. The incorporation of preliminary geotechnical investigation in local byelaws can help to avoid the occurrence of disaster events in design of earth retention system in future.

As geotechnical investigations were not completely carried out on most of the projects

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Unit weight (kN/m³)</th>
<th>Cohesion (kPa)</th>
<th>Friction angle (degree)</th>
<th>Bearing capacity (kPa)</th>
<th>Plasticity index</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL to CL-ML</td>
<td>14 to 19</td>
<td>25 – 50</td>
<td>-</td>
<td>50-70</td>
<td>4 to 7</td>
</tr>
<tr>
<td>ML</td>
<td>15-20</td>
<td>-</td>
<td>26 to 30</td>
<td>60-80</td>
<td>0 to 4</td>
</tr>
<tr>
<td>SM</td>
<td>16-20</td>
<td>-</td>
<td>28 to 34</td>
<td>65-100</td>
<td>-</td>
</tr>
</tbody>
</table>

![Fig. 6. Limits of critical zone lengths around secant piles for external stability.](image-url)
therefore the designers deduced geotechnical parameters based on assumptions (uncontrolled risk). The typical range of basic geotechnical engineering parameters [8] for the soil types reported in Figure 1 is summarized below in Table 4.

In order to select the best possible combination from the range of geotechnical parameters (Table 4) to be used in design external stability check has been applied. For the external stability of earth retention system [6], there are three possible modes of occurrence that can initiate the failure of secant piles as shown in Figure 6. For a secant pile of 0.5 m diameter and 20 m length (5 m embedded and 15 m non-embedded which is mostly employed earth retention system secant pile dimensions) the three possible failure modes distances from the head and toe of the secant piles determined [6] using typical parameters combinations described in Table 4.

The lengths \((a_1, a_2, a_3, b_1, b_2, b_3)\) reflect the limits of critical soil zones around the secant piles with respect to its stability (Fig. 6). Failure surface 3 was observed based on lower limit of geotechnical parameters (Table 4). Failure surface 1 was found using upper bound values of the geotechnical parameters (Table 4). Failure surface 2 was observed from the average of the geotechnical parameters described in Table 4. In actual on most of the projects no clear failure surface pattern (1, 2 or 3) was observed. A combination of patterns was noticed. However, the minimum and maximum limits of lengths described in Figure 6 were observed. Hence, the selection of geotechnical parameters from any reference is a complex phenomena and even an experience professional cannot do it precisely.

Structural design of the earth retention system components were carried out for all the projects. The structure design of earth retention system need parameters deduced from geotechnical investigation like soil cohesion, soil friction angle, bearing capacity, pile end bearing, pile shaft resistance, soil unit weight etc [8]. It can be seen from Table 4 that there are three possibilities of assumptions (uncontrolled risk) which structure engineer have with him; use minimum value, use maximum value or use average value in absence of actually determined value of geotechnical parameter. Table 5 shows different possibilities of assumptions a structure engineer has for geotechnical parameters and impact of these assumptions on different components of earth retention system [6].

Table 5. Summary of possible earth retention system components using different combinations of geotechnical parameters.

<table>
<thead>
<tr>
<th>Earth retention system components</th>
<th>Soil Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case A, Friction Angle = 28°, Unit Weight = 16.5 kN/m²</td>
</tr>
<tr>
<td>Secant pile diameter (m)</td>
<td>0.75</td>
</tr>
<tr>
<td>Secant pile length (m)</td>
<td>25</td>
</tr>
<tr>
<td>Secant pile reinforcement (Number and diameter of steel bar)</td>
<td>8, 25 mm</td>
</tr>
<tr>
<td>Top tie beam dimension (width and height in m)</td>
<td>0.8 x 0.8</td>
</tr>
<tr>
<td>Top tie beam reinforcement (Number and diameter of steel bar)</td>
<td>6, 25 mm</td>
</tr>
<tr>
<td>Anchor beam dimension (width and height in m)</td>
<td>0.4 x 0.4</td>
</tr>
<tr>
<td>Anchor beam reinforcement (Number and diameter of steel bar)</td>
<td>6, 12 mm</td>
</tr>
<tr>
<td>Anchor bonded length (m)</td>
<td>5</td>
</tr>
<tr>
<td>Anchor unbounded length (m)</td>
<td>10</td>
</tr>
<tr>
<td>Anchor diameter (mm)</td>
<td>75</td>
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</tbody>
</table>
Fig. 7 presents a comparison of cost (for a set of earth retention system having 10 secant piles rest same as in the configuration shown in Fig. 3) for each case described in Table 5 using to date construction practices and material rates [12].

The Case A (minimum combination of geotechnical parameter) resulted in undersize and Case C (maximum combination) led to oversize of earth retention system in comparison to Case B (average choice) (Table 5, Fig. 7). The Case B (average combination) is uneconomical with reference to Case A (minimum) and undersize with respect to Case C (maximum) combination. This approach to use assumed geotechnical parameters in structure design of earth retention system may lead the design system either to failure or will make structure uneconomical. It can further be seen from Table 5 and Figure 7 that selection of any combination of geotechnical parameter for structure design of earth retention system is a complex phenomenon. Even for an experienced structure engineer it is cumbersome unless supported by logical preliminary and detailed geotechnical investigation. Additionally, local byelaws of development authority do not address the liability of geotechnical and structure earth retention system design on any design stakeholder [4]. That led to various discrepancies in practice of earth retention system design. The liability of structure as well as the geotechnical earth retention system design should be attributed by development authorities to ensure its safe practice. As per existing local bye laws structure engineers designing any project is always kept liable for his design. However, no liability is attributed to him for the design of earth retention system; this may be the most probable reason that structure engineer take categorical risk of earth retention system design with no or incomplete geotechnical design parameters.

The implementation of construction procedures during each project in comparison with standard construction practice (Table 2) are given in Table 6.

Fig. 8 shows glimpses of construction failures in earth retention system projects.

Drilling of secant piles (J) were carried out in all the projects by rotary drilling machines. The drilling was not carried out as per recognized drilling practices [7]. The verticality, invertness and stability of boreholes were neither maintained nor verified on any project by contractors. It led to the overconsumption of the concrete in secant piles resulting in cost overrun in the activity for owner.

The reinforcement steel (serials K, O, S, Z) bars were not provided in secant piles and tie / anchor beams according to design and technical specifications of the projects. In some projects the verticality of the cage was not maintained and in others the qualities as well as quantity of steel bars
were not adhered as per technical specifications or design. It has been observed that around 5 to 10% of the reinforcement steel bars were reduced in piles/beams in comparison to originally designed bars. The major objective probably in reducing quality and quantity of steel was to curtail the unit cost of activity which was the serious risk by contractor in perspective of the construction project execution ethics.

As per international practice the casting of concrete for secant piles should be through weight batching from concrete batching plant [7]. However, in most of the projects that casting was carried out by conventional concrete mixers through volume batching. In addition the types (coarse and fine) and ratio of concrete ingredients remained out of control by contractors. That led to the attaining of concrete strength lower than the design. The records of compressive strength of different cubes and cylinders casted from the concrete samples of secant piles reflect that the volume batched concrete showed around 10 to 20% lesser strength than the design. This was an uncontrolled risk taken by contractor in the project.

In most of the projects, the wooden shuttering material (N, R, Y) was used in place of steel. That resulted in under/over compaction and improper dimension achievement of beam members.

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**Table 6. Summary of construction activities adopted in each investigated project.**

<table>
<thead>
<tr>
<th>Const.</th>
<th>Projects Serial</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>x x x x x x x x x x x x x x x x x x x x</td>
</tr>
<tr>
<td>K</td>
<td>* * * * * * * * * * * * * * * * * * * *</td>
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<td>L</td>
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<td>δ</td>
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<tr>
<td>ε</td>
<td>x x x x x x x x x x x x x x x x x x x x</td>
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x (Completely Performed), - (Not Performed), * (Incomplete Performed)
This was reflected through the origination of honeycombing on the beam surfaces at different location. The concrete earth retention beams casted with inappropriate shuttering by contractors led to reduce compressive strength of concrete than the originally anticipated in design. The shuttering quality compromise was another uncontrolled risk taken by contractor.

In some of the projects, deep exaction \((Q, X, \varepsilon)\) was carried out using mechanical excavator. The excavated material was transported from the site location through dump trucks. While on others it was manually executed and excavated material was transported from the site through the two sided bags loaded on donkeys. The mechanical method was quick but costly. The manual method was cheaper but time consuming. Both methods have merits and demerits. However, both were risk free as far as quality or procedure of carrying out of activity was concerned \([10, 11]\).

In most of the projects, the diameter of the anchors, bonded/unbounded lengths of anchors were not used \((U, V, W, \beta, \gamma, \delta)\) by contractors as originally anticipated in design. The quality and application of the grouting epoxy and clamping materials used was also not up to mark. The methodology of manual anchor boring at certain inclination angle was also slack. The non standardized anchors installation was key risk taken by contractor on the project.

The construction shortcomings discussed above referred to the inadequacy of project management and lack of quality control and assurance on the projects. Further excessive risks taken on the projects referred to out of control risk management which is extremely dangerous practice for the construction projects. Due to design or construction shortcomings described above the projects originally anticipated costs overran as shown in Fig. 9.

The projects at serial nos. 2, 3, 4 and 5 (Table 1) which faced partial design disaster of earth retention
system showed 50 to 70% increase in its original contract cost of earth retention at completion after necessary rehabilitations (Fig. 9). The partial construction failures of earth retention system in projects serials 6, 13, 14, 15, 16, 17, 18 and 19 (Table 1) finished in almost more than double of the original cost of earth retention at completion after repair. In significant cost variation was observed in cost of earth retention in remaining projects which faced limited design or construction debacles.

4. CONCLUSIONS

The earth retention system disasters were caused primarily due to insufficiency in the existing byelaws of the local development authorities. In addition, lack of implementation of geotechnical engineering, project management and risk management practices were also the major reasons of disasters.

The main geotechnical engineering design and construction factors that caused the failures were inappropriate spacing of anchor piles, deficient anchors installation methodology, underestimating the soil behavior and pressures, incomplete understanding of geotechnical design/implementation. The major project management design and construction factors those contributed failures were deficient constructability, improper deep excavation methodology and lack of quality control/assurance during design/construction. The key risk management features that led to the failure include improper risks management, insufficient risks identification and lack of precautionary measures after taking uncontrolled risks.

5. RECOMMENDATIONS

Based on this study, the following recommendations are proposed as prevention measures to avoid future disasters in earth retention systems:

1. Local byelaws of development authorities should incorporate the implementation of preliminary geotechnical investigations prior to detailed geotechnical investigation.

2. Structure engineer should design the earth retention system structure after incorporation of necessary geotechnical parameters deduced from preliminary and detailed geotechnical investigations. Earth retention system design should be verified though a structure stability certificate by the local development authorities. The certificate should be mutually signed by professional geotechnical and structural engineer.

3. Geotechnical design of earth retention system must be carried out using actual parameters deduced from preliminary and detailed
geotechnical investigation otherwise either the design will be under design or uneconomical. Local development authorities should also impose liability on geotechnical engineer for design safety of earth retention system.

4. The owner/client of the project should hire the advisory services from licensed professional construction individuals or enterprises. The historic or surrounding geotechnical data can only be used as reference during feasibility. However, independent geotechnical investigation should be carried out before detailed design of earth retention system for the project.

6. ACKNOWLEDGEMENTS

The author is thankful to all the stakeholders of the projects for the support in collection of sensitive details and facts related to the projects for its research-based use.

7. REFERENCES

Novel Photo-Neutron Oriented Dynamic Modeling and Synthesis of Robust Global Power Controllers for CANDU-6 Nuclear Reactor using Modern Optimization Techniques

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2Department of Management Information System, Pakistan Atomic Energy Commission, B-63, Block-B, Kazimabad, Model Colony, Karachi, Pakistan

Abstract: In this research paper, the nonlinear dynamics of a modern CANadian Deuterium Uranium (CANDU) nuclear reactor called CANDU-6 is modeled in detailed with special emphasis on photo neutrons dynamics for the first time in CANDU reactor technology. A new strategy is adopted for global power control of modern CANadian Deuterium Uranium (CANDU) nuclear reactor called CANDU-6. Instead fourteen Multi-Input Multi-Output (MIMO) liquid zone controllers for reactor power control of CANDU-6 in fourteen zones, a Single-Input Single-Output (SISO) much simplified Proportional plus Integral plus Derivative (PID) Controller is designed using very fast convergence Nelder-Mead Algorithm (NMA) as benchmark controller based on CANDU-6 design specifications. The closed loop performance of CANDU-6 is further attempted and enhanced with Nonlinear Fuzzy Logic Controller (N-FLC) using Mamdani Inference Engine (MIE). The closed loop performance of both proposed new controllers are tested under normal and reactivity disturbance conditions and found highly remarkable and robust.

Keywords: Photo neutron dynamics, Nelder-Mead algorithm, Mamdani inference, global power control, reactivity disturbance, CANDU-6

1. INTRODUCTION

The CANDU-6 reactor is an advanced Pressurized Heavy Water Reactor (PHWR) of 600 MWe power rating. In this research work, the large nuclear reactor core of CANDU-6 [1] is broadly focused for global power control.

There are some models available for PHWR-type nuclear reactors in nuclear reactor codes but their complex nature does not allow model-based controller design [2, 3]. A core power distribution of 540 MWe large PHWR-type nuclear reactor is estimated using neural network technique [4]. A MIMO highly nonlinear dynamics of 137 MWe CANDU is captured using adaptive feedforward neural network in [5]. A spline wavelet transform based nonlinear dynamics of 540 MWe Indian PHWR has been modeled using liquid zone control concept for advanced CANDU reactors [6].

A nodal model of large 540 MWe Indian PHWR-type nuclear reactor has been developed, model order reduction has been performed and different controllers have been proposed like linear quadratic regulator control, periodic decentralized control and nonlinear sliding mode control [7-10] for xenon oscillations based spatial control. A fuzzy logic based controller has been designed for pressure regulation in liquid zone control system for 540 MWe large PHWR [11] so that power can be regulated in fourteen liquid zones.

The reactor dynamics of large PHWR have been addressed with six group delayed neutrons, temperature feedbacks of fuel and coolant and xenon
reactivity feedback [7–10]. In this research work, a new model is developed with special emphasis on eleven groups of photo neutrons. Further, a Proportional plus Integral plus Derivative (PID) controller is designed using modern tuning Nelder-Mead Algorithm (NMA) with great reduction in objective function value in early iterations for global power control of CANDU-6 reactor rather than complex coupled fourteen liquid zone power controllers. Hence, it reduces the complexity of the controller design by a greater extent. A robust nonlinear Mamdani type fuzzy logic controller has been designed using triangular membership functions and tuned under sequence of step load variations and bounded reactivity disturbances. Both PID and fuzzy logic controllers have been found highly robust as these controllers rejects reactivity disturbances with great extent under different ramp transients.

2. MATERIALS AND METHODS

2.1. CANDU-6 Reactor Power Control System

In advanced CANDU-6 reactor, the reactor power control system consists of liquid zone control system, mechanical absorber control rod system and adjuster rod control system. Amongst these three power control system, the liquid zone control system is the main reactor control system which is addressed in this research work. In this scenario, the mechanical absorber rods and adjuster control rods are remained inactive and reactor power is being controlled with liquid zone control system only.

2.2. CANDU-6 Liquid Zone Power Controllers

CANDU-6 reactor has a liquid zone control system capable of handling ±3.5 mk reactivity. This ±3.5 mk reactivity is controlled by means of fourteen liquid zone controllers. The liquid zone control system consisting of fourteen compartments filled with light water while heavy water is used as main moderator filled in a main outer cylindrical shape reactor core called calandria. The interaction of moderator with nuclear fuel results in the production neutron power. The light water has higher absorption cross-section as compared to heavy water. Therefore, the variation of light water drastically changes the reactivity and thereby the reactor power in each compartment. Hence, the level of liquid in each compartment is changed very finely so that the power variation should be very much smooth. Since there are fourteen compartment, so there must be coupling between each two liquid compartment that makes the control too difficult and complex.

2.3. Novel CANDU-6 Reactor Model Development

In this research work, neutron power \( n(t) \), four group delayed neutron precursor concentrations \( C_i(t) \), eleven group photo neutron precursor concentrations \( C_j(t) \), global moderator level \( H(t) \), fuel temperature \( T_F(t) \), coolant temperature \( T_C(t) \), xenon concentration \( X(t) \) and iodine concentration \( X(t) \) are considered. Therefore, there are twenty one state variables and hence the order of system is twenty one.

The dynamics of neutron power and four group delayed neutron precursors can be modeled as [7]:

\[
\frac{dn(t)}{dt} = \frac{\rho(t) - \beta}{l} n(t) + \sum_{i=0}^{4} \lambda_i C_i(t) \tag{1}
\]

\[
\frac{dC_i(t)}{dt} = \frac{\beta_i}{l} n(t) - \lambda_i C_i(t) \tag{2}
\]

where \( \rho(t) \), \( \beta_i \), \( l \) and \( \lambda_i \) are the reactivity, four group delayed neutron fractions (U-235, U-238, Pu-239 and Pu-241), neutron life time and precursor decay constants associated with four group delayed neutron fractions respectively.

The dynamics of eleven group photo neutron precursors can be modeled:

\[
\frac{dC_j(t)}{dt} = \frac{\beta_j}{l} n(t) - \lambda_j C_j(t) ;
\]

\( j = 5, 6, 7, ..., 15 \tag{3}\)

where \( \rho(t) \), \( \beta_j \), \( l \) and \( \lambda_j \) are the reactivity, eleven group photo neutron fractions, neutron life time and precursor decay constants associated with eleven group photo neutron fractions respectively.
The variation of liquid level in the light water compartment can be modeled as:

\[
\frac{dH_k(t)}{dt} = -LQ_k(t) \quad ; \quad k = 1,2,3,\ldots,14
\]  

(4)

where, \(H_k(t)\) is the instantaneous water level in the \(k^{th}\) zone, \(L\) is the proportionality constant and \(Q_k(t)\) is the input signal given to the control valve of the \(k^{th}\) zone.

The total liquid level and in-flow in all compartments can be computed as:

\[
H(t) = \sum_{k=1}^{14} H_k(t)
\]  

(5)

\[
Q(t) = \sum_{k=1}^{14} Q_k(t)
\]  

(6)

Therefore, the liquid level variation for global power can be computed as:

\[
\frac{dH(t)}{dt} = -LQ(t)
\]  

(7)

The heat balance for the fuel can be written as:

\[
m_Fc_F \frac{dT_F(t)}{dt} = a_Fn(t) - h[T_F(t) - T_C(t)]
\]  

(8)

where \(a_F\) is the fuel proportionality constant and \(h\) is the fuel heat transfer coefficient.

The heat transfer to the coolant can be computed as:

\[
m_Cc_p \frac{dT_C(t)}{dt} = h[T_F(t) - T_C(t)] - 2Q_Cc_p[T_C(t) - T_{C_w}(t)]
\]  

(9)

where \(C_{p_C}\) is the specific heat capacity at constant pressure and \(Q_C\) is the coolant flow rate.

The Iodine dynamics can be formulated as:

\[
\frac{dI(t)}{dt} = \gamma_I \sum n(t) - \lambda_I I(t)
\]  

(10)

where \(\gamma_I\), \(\sum n\) and \(\lambda_I\) Iodine yield fraction, fuel fission macroscopic cross-section and Iodine decay constant respectively.

The Xenon dynamics can be formulated as:

\[
\frac{dX(t)}{dt} = \gamma_X \sum n(t) + \lambda_X I(t) - [\lambda_X + \sigma_X(t)n(t)]X(t)
\]  

(11)

where \(\gamma_X\), \(\sigma_X\) and \(\lambda_X\) Xenon yield fraction, Xenon absorption cross-section and Iodine decay constant respectively.

Equation (11) is highly nonlinear in nature since the third term containing the product of two time dependent parameters \(n(t)\) and \(X(t)\).

2.3.1. Linearization of CANDU-6 Reactor Model

21st order nonlinear CANDU-6 reactor model described in equations (1) to equation (3) and equation (7) to equation (11) are linearized using small perturbation method in which small deviations are allowed around all twenty one state variables and substituting all derivative terms equal zero.

2.3.2. Linearized CANDU-6 Reactor Model

After linearization, all the state equations are arranged in standard state space form as:

\[
\frac{dx(t)}{dt} = A_{21x21}x(t) + B_{1x21}u(t)
\]  

(12)

\[
y(t) = C_{2x1}x(t) + D_{1x1}u(t)
\]  

(13)

Where \(x(t)\) represent the state vectors of the system, \(y(t)\) and \(u(t)\) are the output and input vector of the system respectively, \(A_{21x21}\) is the system state matrix, \(B_{1x21}\) is input matrix, \(C_{2x1}\) is the output matrix and \(D_{1x1}\) is direct transmission matrix.

The state vector for the model can be defined as:

\[
x(t) = \begin{bmatrix}
\delta n(t) \\
\delta C_1(t) \\
\delta C_2(t) \\
\vdots \\
\delta C_{15}(t) \\
\delta I(t) \\
\delta X(t) \\
\delta H(t) \\
\delta T_F(t) \\
\delta T_C(t)
\end{bmatrix}
\]  

(14)

\[
I_0 \\
X_0
\]

2.3.3. Nelder-Mead Algorithm

The parameters of global PID controller are optimized using a Nelder-Mead optimization algorithm. The fast optimization and convergence
is achieved through simplex, expansion, contraction and shrinkage processes [12].

2.3.4. Integrated Time Absolute Error
The integral error is generally accepted as a good measure for control system performance and this performance is computed as the Integrated Time Absolute Error (ITAE).

2.4 New Global PID Controller
In this research work, instead of 14 liquid controllers, a new single PID controller was designed for global power control of CANDU-6 reactor. The PID controller generates a total control demand \( u(t) \) which is computed using the following control law:

\[
u(t) = K_p e(t) + \frac{1}{T_i} \int e(t) dt + T_d e(t)
\]

where \( K_p, T_i \) and \( T_d \) are the proportional gain, integral time constant, derivative time constant respectively.

The error signal \( e(t) \) is the signal between reference signal \( r(t) = \text{Reference Power Set-Point (MWth)} \) and the controlled signal \( y(t) = \text{Reactor power output (MWth)} \), which can be defined as:

\[
e(t) = r(t) - y(t)
\]

2.5. Nonlinear Fuzzy Logic Controller

2.5.1. Structure of Fuzzy Logic Controller
Fuzzy logic controller is basically an intelligent controller. It is well suited when system models are too complex. It is a nonlinear controller. The use of fuzzy logic enables to model a nonlinear controller with IF-THEN fuzzy rules. The measure of fuzziness is determined using a membership function spread over the entire range of operation of parameter or variable. The purpose of membership function is to convert the degree of fuzziness into the normalized interval [0, 1]. There are several membership functions like triangular, trapezoidal, Gaussian, and bell-shaped forms and even a user defined membership can be defined. The internal structure of fuzzy logic controller is constituted upon fuzzifier unit, inference engine and knowledge base or Fuzzy rule base and defuzzifier unit as shown in Fig. 1. The fuzzifier converts the real parameters also called crisp input into fuzzy sets and this process of conversion is known as fuzzification. The fuzzy rule base is basically a knowledge base containing rules for decision making. A Fuzzy inference engine is a system that maps the fuzzy inputs to the fuzzy output using fuzzy sets and fuzzy rule base. The inference engine is basically the heart of the fuzzy logic controller. The defuzzifier converts the fuzzy sets into real parameters now called crisp out.

2.5.2. Operation of Fuzzy Logic Controller
The operation of inference engine basically constituted upon three units called aggregation unit, implication unit and accumulation unit. In aggregation unit, each rule is evaluated in first phase. In second phase, in implication unit, the consequent of each rule is constructed. In third phase, in accumulation unit, the implied fuzzy set from the implication unit for each rule are accumulated through the union operator to finally produce the accumulated fuzzy set.

3. RESULTS AND DISCUSSION
In this section open and closed loop analysis of CANDU-6 reactor power control system is presented and discussed.

3.1. Open Loop Analysis of CANDU-6 Reactor Model
The state space linearized model of CANDU-6 reactor described in equations (12) and (13) is solved based on CANDU-6 reactor design as reported in [1] using MATLAB. The corresponding open loop eigenvalues or poles are computed as shown in Table 1. Since the first open loop pole is located at origin and second pole is positive, therefore the CANDU-6 reactor is inherently unstable. All the remaining eigenvalues are negative and too small in amplitude, so the dynamics of CANDU-6 reactor is critically damped. The open loop Bode magnitude and phase frequency plots are shown in Fig. 3.
Fig. 1. Design structure of fuzzy logic controller.

Fig. 2. Operation of fuzzy logic controller.
Table 1. Location of complex poles of the open loop system in s-plane.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Complex Poles Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0000E+00</td>
</tr>
<tr>
<td>2</td>
<td>8.1763E+00</td>
</tr>
<tr>
<td>3</td>
<td>-3.8740E+00</td>
</tr>
<tr>
<td>4</td>
<td>-1.5457E+00</td>
</tr>
<tr>
<td>5</td>
<td>-4.3376E-001 +1.0186E-02i</td>
</tr>
<tr>
<td>6</td>
<td>-4.3376E-001 -1.0186E-02i</td>
</tr>
<tr>
<td>7</td>
<td>-2.7927E-01</td>
</tr>
<tr>
<td>8</td>
<td>-1.3300E-01</td>
</tr>
<tr>
<td>9</td>
<td>-4.1537E-02</td>
</tr>
<tr>
<td>10</td>
<td>-3.4681E-02</td>
</tr>
<tr>
<td>11</td>
<td>-1.6985E-02</td>
</tr>
<tr>
<td>12</td>
<td>-4.8200E-03</td>
</tr>
<tr>
<td>13</td>
<td>-1.5023E-03</td>
</tr>
<tr>
<td>14</td>
<td>-8.1284E-04</td>
</tr>
<tr>
<td>15</td>
<td>-5.8860E-04</td>
</tr>
<tr>
<td>16</td>
<td>-4.2790E-04</td>
</tr>
<tr>
<td>17</td>
<td>-1.1701E-04</td>
</tr>
<tr>
<td>18</td>
<td>-4.3701E-05</td>
</tr>
<tr>
<td>19</td>
<td>-9.0071E-06</td>
</tr>
<tr>
<td>20</td>
<td>-3.6302E-06</td>
</tr>
<tr>
<td>21</td>
<td>-6.2601E-07</td>
</tr>
</tbody>
</table>

3.2. Design of Global PID Controller for CANDU-6 Reactor

On investigating the open loop eigenvalues presented in Table 1, it is evident that one pole is located at 0.00+0.00i. Therefore, the value of integral gain ($K_i$) which is reciprocal of integral time ($T_i$) is set equal to zero. Hence, the PID controller is simply reduced to PD controller. The design parameters of the PD controller are optimized in closed loop configuration using Nelder-Mead optimization algorithm. The tuned optimal values of PD controller are presented in Table 2. The closed loop eigenvalues with optimal PD controller are shown in Table 3. Since all the eigenvalues are negative, therefore now the system is stable and controllable.

Table 2. Optimal PD controller parameters.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Controller Parameters</th>
<th>Optimal Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$K_p$</td>
<td>1.1987E-01</td>
</tr>
<tr>
<td>2</td>
<td>$T_d$</td>
<td>4.7041E-01</td>
</tr>
</tbody>
</table>

Table 3. Location of the complex closed loop poles in s-plane.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Poles Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-3.6708E+02</td>
</tr>
<tr>
<td>2</td>
<td>-3.7830E+00</td>
</tr>
<tr>
<td>3</td>
<td>-1.3846E+00</td>
</tr>
<tr>
<td>4</td>
<td>-4.4336E-01</td>
</tr>
<tr>
<td>5</td>
<td>-2.9876E-01</td>
</tr>
<tr>
<td>6</td>
<td>-2.7675E-01 +1.0309E-02i</td>
</tr>
<tr>
<td>7</td>
<td>-2.7675E-01 -1.0309E-02i</td>
</tr>
<tr>
<td>8</td>
<td>-1.2223E-01</td>
</tr>
<tr>
<td>9</td>
<td>-4.1129E-02</td>
</tr>
<tr>
<td>10</td>
<td>-3.1571E-02</td>
</tr>
<tr>
<td>11</td>
<td>-1.6900E-02</td>
</tr>
<tr>
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<td>-4.8100E-03</td>
</tr>
<tr>
<td>13</td>
<td>-1.5000E-03</td>
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</tr>
<tr>
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<td>-4.2800E-04</td>
</tr>
<tr>
<td>16</td>
<td>-2.8068E-04</td>
</tr>
<tr>
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<td>19</td>
<td>-2.8780E-05</td>
</tr>
<tr>
<td>20</td>
<td>-3.6300E-06</td>
</tr>
<tr>
<td>21</td>
<td>-6.2600E-07</td>
</tr>
</tbody>
</table>

3.3. Design of Global Nonlinear Fuzzy Controller for CANDU-6 Reactor

The fuzzy logic controller is designed based on two inputs as power error and rate of power error respectively. Triangular membership functions are chosen for power error and rate of power error inputs. The membership functions for the power error and rate of power error are shown in Fig. 4 and Fig. 5 respectively. The universe of discourse for the power error input is [-30 30] and rate of power error is [-10 10]. The global nonlinear fuzzy logic controller computes the reactor power as output based on the value of the inputs and the associated rules and output membership function. Similarly, triangular membership functions are selected for output. The membership function for the output is [-7.5 7.5]. Twenty five rules are defined for the fuzzy rule base as shown in Table 4. The surface view and mesh plot of design rules are shown in Fig. 7 and Fig. 8 respectively. The design of proposed fuzzy logic controller is shown in Fig. 9. Two adjustable gains $G_1$ and $G_2$ are used in the design for the fine tuning of rules and hence for the
Fig. 3. Open loop magnitude and phase Bode plot of CANDU-6 reactor model.

Fig. 4. Membership function for error input.
Fig. 5. Membership function for rate of error input.

Fig. 6. Membership function for output.

Fig. 7. Surface view of design rules.
optimization of nonlinear fuzzy logic controller parameters for keeping the closed loop response within the desired bounds. The values of adjustable gains $G_1$ and $G_2$ are optimized and found 5 and 0.2, respectively.

**Table 4.** Rules for Global FLC design for CANDU-6 reactor power control.

<table>
<thead>
<tr>
<th>Output</th>
<th>N2</th>
<th>N1</th>
<th>Z</th>
<th>P1</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of Error</td>
<td>N2</td>
<td>N2</td>
<td>N2</td>
<td>N1</td>
<td>Z</td>
</tr>
<tr>
<td></td>
<td>N1</td>
<td>N2</td>
<td>N2</td>
<td>Z</td>
<td>P1</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>N2</td>
<td>N1</td>
<td>Z</td>
<td>P1</td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>N1</td>
<td>Z</td>
<td>P1</td>
<td>P2</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>Z</td>
<td>P1</td>
<td>P2</td>
<td>P2</td>
</tr>
</tbody>
</table>

### 3.4. Evaluation of New Closed Loop CANDU-6 Reactor Control Systems for Global Power

The closed loop performance of new controllers is tested in reference tracking mode. The reference tracking controller is one in which output reactor power follows the reference or set-point or target reactor power. In order to assess the stability and reference tracking capability of proposed controllers, a sequence of set-point changes has been introduced in this design as shown in Fig. 10. It is quite evident that both controllers track the set-point changes in a very efficiently manner but fuzzy controller is observed much faster as compared to PID controller. Since there are twenty one state variables, so it is not possible to present all results in this paper. However, a new addition in
Fig. 10. Comparison of reactor power response based on PID and Fuzzy Controllers.

Fig. 11. Comparison of photo neutron concentration response based on PID and Fuzzy Controllers.
Fig. 12. Positive reactivity disturbance of different magnitudes.

Fig. 13. Reactor power variations for different positive reactivity rates with PID controller.
Fig. 14. Photo neutron concentration variations for different positive reactivity rates with PID controller.

Fig. 15. Reactor power variations for different positive reactivity rates with Fuzzy controller.
this paper is the dynamics of photo neutrons, so its response analysis has been mainly focused in this research work. The comparison of photo neutrons concentration response based on PID and fuzzy controllers is shown in Fig. 11. The comparison response shows that both controllers mimics perfectly.

3.5. Robustness Analysis of New Closed Loop CANDU-6 Reactor Control Systems for Global Power

Robustness analysis of both new controllers is assessed by introducing reactivity disturbance. Positive reactivity disturbances of different magnitudes ranging from 0.5 mk to 3.5 mk are introduced via sequence of ramp transients as shown in Fig. 12. Reactor power variations for these positive reactivity disturbances are assessed with PID controller and shown in Fig. 13. These power variations are well within the design bounds as reported in [1]. Photo neutrons concentration variations for these positive reactivity disturbances are assessed with PID controller and shown in Fig. 14. Reactor power variations for these positive reactivity disturbances are assessed with fuzzy controller and shown in Fig. 15. These power variations are much faster in response as compared to PID controller. Photo neutrons concentration variations for these positive reactivity disturbances are assessed with fuzzy controller and shown in Fig. 16. Hence, it is proved that a successful realization has been achieved for attaining critically damped CANDU-6 reactor through simulation experiments.

4. CONCLUSIONS

A 21st order higher order nonlinear dynamic model for modern CANDU-6 reactor has been developed for global power control based on core neutronics, thermal feedbacks, xenon poisoning and photo neutrons. A higher order model is linearized and a PID controller has been successfully designed in SISO configuration. Based on PID controller dynamics, a nonlinear fuzzy logic controller has been designed with improved performance and robustness. The performance of both proposed controllers has been tested in reference tracking mode. Both controllers have been proven highly robust under disturbance conditions. But the
nonlinear fuzzy logic controller has been found faster in tracking mode.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Identification of Neotectonics using DEM-based Local Base-level Approach in Pothowar Plateau

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Abstract: The isobase map (local base-level map) represents the erosional stages and it gives a strong relationship between different Strahler order streams and the local erosion al conditions in a changing topography. This approach is quick, efficient and reliable to delineate neotectonic influence within the same rock types. In this research, we evaluate the geomorphic landforms of Pothowar Plateau and Kalabagh fault zone using local base level approach. The purpose is to demarcate boundaries and to see whether they are influenced by the active tectonics or lithologic difference. For this purpose, we extracted the drainage network in the form of second and third order Strahler streams and automatic lineaments (by Houghman transformation) from SRTM 90m DEM. The isobase map was constructed based on the points of intersection of automated contours from the DEM and with the selected stream orders. We observed different base-level anomalies that relate to the prominent neotectonic features and lithological boundaries as presented in the published geological maps. The orientation, deflection and disconnection of the isobase lines correspond well with the local structures in the study area.

Keywords: SRTM DEM, Strahler orders, isobase, neotectonics, Potowar Plateau, Kalabagh fault zone, Uyt

1. INTRODUCTION

The dynamics of stream Strahler orders and topographic variations can be investigated by using an isobase map [1–3]. The isobase is a term which is used for a line that demarcates an erosional surface or a line of equal uplift (e.g., just in case of isobars and isotherms). The isobase surface is a hypothetical plane formed by connecting stream profiles of a similar stream order [4]. Therefore, this parameter is a handy tool to decode neotectonic signals preserved in the concerned landscape. The isobase level map is taken as a vital tool to identify neotectonic processes. The isobase lines show possible and different erosional/tectonic stages within a given study area. These erosional stages maybe related to erosional cycles as suggested by Davisian scheme. These erosional cycles can be attributed to the most current ones and maybe due to the lithologic contrast/tectonics scarps.

According to Golts and Rosenthal [1] the isobase map of the Arava (segment of the Jordon Dead Sea Rift Valley) revealed that a young sedimentary basin is explained by a plain and weak incised relief, and is valuable for the seismic studies. Zuchiewicz, and Oaks [5] used a topographic sheet at a scale of 1:100,000 scale and prepared isobase maps by using first, second and third stream Strahler order. We observed actual landscape whereas the third order isobase map was quite capable to show pronounced lineaments/faults/folds. According to Sant’Anna et al [6] the morphotectonic map of Fonseca Basin in SE-Brazil endorsed the presence of main structural breaks with north-south and less frequent towards east-west, north-east and north-west orientations.
Grohmann et al [7] prepared an isobase level map using second and third order streams. This map generated the best possible results and its interpretation was found good and consistent with the elucidation of regional scale morphotectonics of Parnaiba Sedimentary province in north eastern Brazil. According to Mahmood et al [8] the isobase map of Hindukush, constructed from second and third order streams, was also consistent with the regional scale morphotectonics in Hindukush and surrounding regions.

The aim of this research was to generate an isobase map for the Pothowar plateau in order to constrain neotectonics; related surface deformation, erosional scarps and their relationship with the local faults/lineaments or lithologic variations.

2. TECTONIC SETTING OF THE STUDY AREA

The Indo-Pakistan Plate belongs to the east Gondwanaland [9]. The Gondwana’s name was kept after the name of a district in India where the fossil plant named Glossopteris was found [10, 11]. The Pothowar plateau emerged as a result of collision between Indian and Eurasian plates that created large scale regional structures (Fig.1). This plateau is roughly defined by the rivers Indus and Jhelum to the west and east, respectively, the Kalachitta-Margalla Hill Ranges to the north, and the Salt Range to the south (Fig.2). It is mostly covered by the Siwalik sequence. Although at places upper Eocene shales and limestones crop out locally in folded inliers. Its northern region, termed as the North Pothowar Deformed Zone (NPDZ) is more deeply deformed. Is it characterized by east-west, tight and complex folds, reversed to the south and clipped by steep-angle faults.

The NPDZ is followed to the south by asymmetrical, wide and broad Soan syncline, with a gently northward dipping southern flank along the Salt Range and a steeply dipping northern limb along NPDZ (Fig.2). In the western part this basin consists of many east-west, broad and gentle folds (wavelength 26-40 km). In its eastern part the strike sharply changes to the northeast and the structures comprise tightly folded anticlines and broad synclines (fold wavelength 10-12 km). Axial zones of most anticlines dip steeply or are overturned. Faulting of the anticlines is rare [12]. This east to west difference in the structural style has been attributed to the reduced thickness of evaporates and lesser basement slope in the eastern part of the Pothowar and Salt Range. Increased drag at the base of the section has formed relatively complicated structures due to greater internal deformation [13].

In the Fig. 1, the GPS velocity vectors (Red) with respect to Eurasia fixed reference frame from the purple vector is transformed from velocities with respect to India fixed. Note the direction and decreasing GPS velocities towards north showing convergence and anticlockwise rotation of India. Abbreviations of fault names: AM, Alburz Marmul, CbF, Central Badakhshan Fault, HF, Herat Fault, CF, Chaman Fault; MoF, Mokar fault, GzF, Gardez Fault, KoF, Konar Fault, MBT, Main Boundary Thrust; MFT, Main frontal thrust, MMT, Main Mantle Thrust, and MKT, Main Karakoram Thrust, Reshun Fault, SF, Sarobi Fault, ST, Spinghar Thrust [14].

3. MATERIALS AND METHODS

We used Shuttle Radar Topographic Mission SRTM DEM (http://srtm.cgiar.org) [15] with spatial resolution of 90 m to extract drainage network of different Strahler orders [16] automatically, e.g., 1, 2, 3 and so on. The local base level map is prepared on the basis of intersection of different stream Strahler orders, for example a third order tributary is a fragment along the downstream, the meeting of any two second order tributary and a third order segment is formed by the confluence of any two third order tributaries and so on as shown in the (Fig. 3). To generate a second order isobase level map, we use all Strahler order tributaries instead those of first order tributaries. Isobase map represents a simplified shape of actual 3D Landscape, where we actually neglect the relief above the isobase surface. Previously, physical generation of isobase maps were a time taking procedure.

Drainage network classification based on different Strahler orders and the explanation of isobase lines needs highly qualitative topo-sheets at appropriate scale. For the DEM based automatic extraction and classification of drainage network permits the required data for a larger area in a quick
Neotectonics in Potowar Plateau using DEM

Fig. 1. Tectonic map of the Hindu Kush-Himalaya-Pamirs-Karakoram showing reported and newly confirmed faults with inset showing the study area [11].

Fig. 2. Location of study area of Pothowar Plateau and Kalabagh fault zone (northern Pakistan) with Landsat bands 742-RGB combination draped over shaded relief map along with major rivers (Indus, Soan and Jhelum) and drainage network.
Fig. 3. Illustration showing Stream Strahler ordering.

Fig. 4(a,b). Illustration showing mechanism of isobase map construction [1].

and efficient manner with no cost [7]. It is observed that the stream Strahler ordering highly rely on spatial resolution of the DEM, which means that high resolution DEM will generate denser stream network and vice versa. It simply means that the main rivers will be representing a higher Strahler order. The DEM based stream network classification along with the elevation points used to interpolate the isobase surfaces can be derived by draping the required stream Strahler orders with the DEM based contours [17] (Fig. 4 a, b).

The exclusion of first order Strahler streams decreases the noise in the digital elevation model that can help improve the detection of a fault scarp/erosional scarp or any other morphotectonic feature that could be significant in the context of topographic development. For instance, the geomorphic development of a thrust fault scarp, the preliminary boundary condition is perturbed by the thrust fault and the knick zones along the river longitudinal profile explain the convex up/ concave down profiles, because of the thrust evolution different boundaries of erosional surface and accordingly the profile geometry development, such that the erosional processes start appearing significant in
different stages. According to Zuchiewicz and Oaks [5], $10^5$-$10^6$ years are adequate to fade out a recently developed tectonic scarp to a stage somewhere, all the off cuts have been removed.

For the automatic extraction of lineaments/faults we used Houghman transformation (an algorithm in the Geomatica software v.9.1) which is quite capable of isolating features of a particular shape (e.g., lineaments, ridges and sharp edges, etc.) within an image (e.g., Digital Elevation Model).

The Hough transform can be used to identify the parameter(s) of a curve which best fits a set of given edge points. This edge description is commonly obtained from a feature detecting operator such as the Sobel or Canny edge detector and may be noisy, i.e., it may contain multiple edge fragments corresponding to a single whole feature. In addition, as the output of an edge detector defines only where features are in an image, the work of the Hough transform is to determine both what the features are (i.e., to detect the feature(s) for which it has a parametric (or other) description) and how many of them exist in the image. The lineaments obtained using above mentioned method have been analyzed in the context of anomalies found in drainage network analysis.

4. RESULTS AND DISCUSSION

Keeping in view the past studies regarding the understanding of regional scale morphotectonics, the isobase map for the Pothowar Plateau and Kalabagh fault zone was prepared using second and third stream Strahler orders (Fig. 4). This map found good to reveal the excellent results. We generated isobase contours with different spatial intervals (50 m, 100 m, 200 m, 300 m, 400 m, 500 m) using ArcGIS 10 and prepared isobase maps as shown in (Fig.5–9). Both small and large structures can be identified from the generated isobase maps in the visual context. Some of these structures are associated with neotectonic activity.

The ellipse # 1 (Fig. 5) shows the Attock-Cherat-Range (ACR). We can clearly observe

Fig. 5. Isobase map with isobase contour lines with spatial interval of 50 m, orange circles, 1,2 and 3 shows Attock-Cherat Range, MBT and Jhelum faults and Salt Range Thrust (SRT).
Fig. 6. Isobase map with 100 m interval isobase contour lines.

Fig. 7. Isobase map with 200 m interval isobase contour lines.
Fig. 8. Isobase map with 300 m interval isobase contour lines.

Fig. 9. Isobase map with 400 m interval isobase contour lines.
Fig. 10. Isobase map with 500 m interval isobase contour lines.

Fig. 11. Isobase map with isobase contour lines automatically extracted red lineaments from SRTM DEM (using Houghman transformations) with spatial interval of 50 m.
the deflection of isobase contour lines which are NE-SW oriented along the NE-SW propagation of the ACR indicating various differential stages of erosion. This deflection indicates that ACR is tectonically active range, and isobase maps reveal a possible of five to six episodes of quick relative neotectonic/erosional up /uplift stages. The existing deep narrow canyons/gorges and valleys in ACR could have been developed due to the episodic neotectonic uplift resulting from the subsequent erosion and shaping. The eroded sediments were dumped in the foothills of the ACR as alluvial fans at the piedmont-mountain junction and plains in the southern Peshawar basin. The isobase maps prepared at isobase contour intervals are shown in the (Fig. 6–9).

The neotectonic activity along ACR is evidenced by the capture of Indus River in a NE-SW direction as initially it was flowing in N-S direction just after the confluence of Kabul and Indus rivers. The river capture is under the neotectonic influence of ACR rather than lithologic one. The ellipse#2 illustrates the region of Main boundary thrust (MBT) and the closely packed isobase lines in this region again reflect the severe nature of E-W oriented thrust faulting. A strong E-W orientation of the isobase lines evidences the orientation of the MBT. This zone tips-off a major drainage capture as the Jhelum River flows in a SSE, SSW and then SSE direction again while making sudden inflexions in a very short span of distance. The quick inflexion of the rivers dictates the strong neotectonic influence over the Jhelum River.

The ellipse #3 in the isobase map represents the region of Salt Range in Potowar Plateau, which shows relatively more erosion as compared to MBT and ACR. It means that the Salt range is may be less active seismically in comparison to MBT and ACR which are more active tectonically as they show higher local bas level values. Higher isobase values are indicators of more uplifted conditions/less eroded areas. Some 60 km north of Mianwali, at Kalabagh site, the Indus River is captured by the dextral Kalabagh fault. A prominent NE-SW inflexion of the river can be observed clearly while Indus River makes an exit from Potowar Plateau. The higher isobase values in the north-eastern section of the Salt Range Thrust (SRT) are higher as compared to the south-western and central parts of the SRT, Which means that all these three different parts of the SRT shows differential erosion rates which is another indication of the non-steady state environment or zones of differential relative uplift rates. In (Fig. 10), the alignment of automated lineaments reveal that they are very much in accordance with the already published local and regional structures (e.g., in MBT in the NE, ACR in the NW and in entire salt range in southern Pothowar Plateau.

5. CONCLUSIONS

SRTM DEM-based isobase technique has been quite useful, quick and efficient technique for the morphotectonic investigation. In this research, an example from the Pothowar Plateau and its outskirtshas been examined for the differential erosional/neotectonic events. The isobase map prepared from the automated DEM based drainage networkusing second and third stream Strahler orders has generated excellent results which are consistent with the neotectonics of the Pothowar Plateau. The east-west orientation of the MBT, NE-SW orientation of the ACR and NE-SW orientation of the SRT and the resulting major drainage capture of Indus River at ACR and at dextral Kalabagh Fault Zone (KBFZ) correspond to recent tectonic activity. The morpho structures revealed from the isobase map also provides a close visual relationship with the in situ scenario. Isobase maps permit the quick, delineation, recognition and orientation of neotectonics that present either poor or very less exposed expressionson the thematic maps. Free usage of remote sensing data (SRTM DEM) and MATLAB software facilitates state of the art research in the field of tectonic geomorphology.

6. ACKNOWLEDGEMENTS

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7. REFERENCES


1. INTRODUCTION

Radiotherapy is the most widely adopted treatment technique for cancer. Radiation therapy is considered as a progressive field with an unexhausting struggle made by many radiation workers to enhance efficiency while maintaining a minimum compromise on accuracy. Becquerel and Rontgen are the one who have rolled the ball in the field of radiation therapy by discovering X-rays and gamma rays. As these radiations have the tendency to cut down the growth of oncocytes, treatment units like Cobalt-60 units and linear accelerators have been designed to target radiation beams on the region of interest [1]. Besides radiation treatment, surgery and chemotherapy are also preferred for treating tumors and it seems that the rates of tumor cure increases directly with increasing treatment options [2]. The field of radiation treatment progresses from the radiotherapy plans relied on orthogonal radiographs in which structures of interest were highlighted by large margins to more advanced imaging methods and planning softwares that provided the likelihood of more conformed radiotherapy and then further moved to Intensity Modulated Radiation Therapy (IMRT) [3].

Radiation treatment can either be external beam or internal beam therapy (brachytherapy). Treatment units like Cobalt-60 and LINACs are constructed to perform external beam therapy. In spite of the reduced maintenance and cost effectiveness of cobalt units, LINACs are the preferred the options for radiotherapy due to
their incomparable versatility and working in dual beam modalities (electron beam or photon beam). Megavoltage photon beams from LINACs own the skin-sparing effect by sending radiation beams deeper in the body to treat deep residing tumors [4, 5].

Prior to make clinical use of treatment units, they have to undergo testing and commissioning by concerned persons. Owing to the perils caused by the radiations, commissioning must be performed steadily and with extreme level of precautions. This includes the generation of dose data by measuring percent depth doses in water phantoms which are selected by the dosimetry protocols as a reference material [6]. The processing and checking of beam data is as important as its generation before sending to the planning software which is responsible for calculating patient doses. Accurate beam data is very indispensable to form a model of dose calculation [7]. When standards for the generation of radiotherapy plans and its delivery are satisfied, treatment units can then be sent for treating actual patients [8]. This steady and methodical process normally requires a period of 6-7 months. In order to make the treatment plan more efficient, we have used Lagrange’s Interpolation Method [9] to calculate percentage depth doses at various depths in a limited time span of 3-4 weeks.

2. METHODS FOR ABSORBED DOSE CALCULATION

Determination of dosimetric data is one of the most significant steps which must be taken during commissioning of the newly installed treatment units. This dose data is produced by calculating percentage depth dose (PDD) at increasing depths and for a number of field sizes in dummy patients, which may require a long time period. In order to shorten the time of commissioning, method of Lagrange’s Interpolation has been used in this exploration for the calculation of percentage depth doses at various depths and its required expression is given below.

\[
P_n(x) = \frac{y_0}{(x_0 - x_1) (x_0 - x_2) ... (x_0 - x_n)} + \frac{y_1}{(x_1 - x_0) (x_1 - x_2) ... (x_1 - x_n)} + ... + \frac{y_n}{(x_n - x_0) (x_n - x_1) ... (x_n - x_{n-1})}
\]

In this practice, percentage depth dose can be calculated for discrete depths and field sizes, with some reasonable step size, the rest of data can be interpolated to make that date continuous. Different interpolation techniques are available, but Lagrange’s interpolation method [9] was opted in this attempt, for having a better accuracy, and its algorithm is convenient to be transformed in any object oriented programming language like JAVA, C++ or other. The dose in water or other patient equivalent phantoms are measured only for few discrete depths and field sizes, and the remaining data can be calculated using this method. \(P_n(x)\) will generate the required point dose, for the particular depth \(x\), where \(x_0, x_1, ..., x_n\) are the known discrete depths and \(y_0, y_1, ..., y_n\) are the known dose values.

3. RESULTS

The results are obtained by calculating percentage depth doses (PDDs), comparing the calculated data with standard data [10] and differences in percentage are then observed. The PDD data is calculated for both 6MV & 15MV X-rays. The measured dose data is chosen at some suitable separation to work as the points of interpolation while the remaining data is calculated through the help of Lagrange’s interpolation method to form a continuous dose data.

The results for 6MV X-rays at an SSD of 100 cm are presented in Table 1. Measured dose data is selected at depths with 5 cm separation and the other data is calculated through lagrangian method of interpolation for various field sizes to ensure the continuity of dose data. The depth varies from 1.5 cm to 25 cm with the step size of 1 cm. the maximum difference went to 1.05%. The differences observed
Verification of Absorbed Radiation Dose for X-rays

are very close to the accuracy and do not cross the accuracy limit which is considered to be reasonable if less than 2%. Some of the differences are so less that they can be regarded as touching the accurate value. Even no difference is seen at 17 cm depth for 40 x 40 cm field size.

Table 1. Percentage difference between measured & calculated PDDs (6 MV).

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Table 2. Percentage difference between measured & calculated PDDs (15 MV).

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On attainment of very useful results, an attempt to further increase the efficiency was made, but increasing the distance gap for interpolation. All the exploration has been repeated for 8 cm distance separation (which was 5 cm previously). The difference remained within acceptable range, and it can offer to use a larger gap, at achieve more efficiency.

Fig. 1 shows the percentage differences graphically for 6 MV X-rays at various depths and field sizes. All the conditions for calculating doses are kept similar except the separation between the depths, at which measured data is selected, is extended to 8 cm with the intent to further enhance the efficiency of treatment plans. The larger peak is close to close 1.2% just beyond the depth of maximum dose. Fig. 2 is the graphical representation of the results for 15 MV X-rays for 10 x 10 cm field size following same conditions at increasing depth
Fig. 1. Percentage difference between measured and interpolated Dose for 10 x 10 –cm field size, 6 MV X-ray.

Fig. 2. Percentage difference between measured and interpolated Dose for 10 x 10 –cm field size, 15 MV X-ray.
Verification of Absorbed Radiation Dose for X-rays

from dmax to the depth of 25 cm. Larger peak is found a bit away from 1.4% but firmly fulfilling the needs of accuracy.

4. DISCUSSION

Percentage depth dose is a function to establish the variation of central axis depth dose which is a crucial step in the system of dosimetric calculations [13]. This step generates a depth dose data produced to foresee the distribution of doses in real cancer patients [14]. For this purpose, mathematical tools like Lagrange’s interpolation method were employed to calculate PDDs with the desired accuracy and efficiency in making radiotherapy plan.

From the results obtained for both 6MV and 15MV X-rays, it is visualized that the d_max of 6MV energies was not as deep as that of 15MV. This is due to the reason that 15MV energy beam is more energetic than the beam of 6MV energy and hence deposits a maximum dose at larger depths. It is clear from the results that the calculated PDD do not differ largely from the standard PDD data for both energy beams at depths with 5 cm separation. This separation has provided a reliable dose data indeed. For the sake of enhancement of efficiency of radiotherapy plans while paying full concentration to the accuracy of dose data, it is seen in graphically shown data that the extended depth of 8 cm has also become successful in providing a reliable dose data. Although the differences observed for extended separation are slightly greater than that for reduced separation yet they strongly fulfills the demands of accuracy and considered as an almost accurate depth dose data.

5. CONCLUSIONS

These investigations focused on increasing efficiency of radiotherapy treatment practices. The suggested numerical approach can reasonably benefit the radiation dosimetrists / medical physicists, not only in a quick commissioning process but also within the accuracy tolerance. It is recommended to measure dosimetric parameters like percentage depth dose, Tissue Air Ratio, Tissue Maximum Ratio etc. on different steps of depth and field size to obtain a discrete set of data. The Lagrange’s interpolation method can be used to fill the data set to make it continuous. The interpolated results precisely agree with the measured data, and can be used as the input data for treatment planning. This exploration should be extended for the interpolation of other dosimetric quantities as well so that the commissioning time can be further decreased and the reliability of the measured data is assured.

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Can We Really Treat Thalassemia Major?

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3Air University, Multan Campus, Pakistan

Abstract: Plant species have proven to be an important source of treatment in different diseases, in particular certain malignant tumors. The cytotoxic efficacy of *Fagonia cretica* has long been a subject of interest. This particular interest in a patient of breast cancer helped us to ascertain the efficacy of this herbal plant in Thalassemia. In initial testing, we obtained encouraging results by using dried aerial parts of the whole plant. It obligated upon us a detailed study of the plant in Thalassemia. A powder of the dried aerial parts of the whole flowering plant was given in doses of 120 mg/kg body weight. The hematological and clinical results in nine Thalassemia Major group, showed a decrease of the Hb F from 97.45 to 10.82% and increase of Hb A from 0.33 to 85.5% (P<0.05) after about nine months of treatment, when blood samples for electrophoresis were collected at least six weeks after transfusion. The size of the liver and spleen which were 4-9 cm palpable below costal margins before treatment were not palpable after nine-month treatment. Similarly, in all the six patients, suffering with *Thalassemia intermedia* total hemoglobin improved from 2.13-5.6 g (P<0.05). Mean values of hemoglobin before and after the treatment were 8.08 and 11.95 g, respectively. In the four patients suffering with Thalassemia minor mean values of Hb A2 were 5.25 and 3.30, respectively before and after; and the reduction in Hb A2 was significant with 0.13 to 3.77% (P<0.05).

Keywords: Thalassemia, *Fagonia cretica*, genetic mutation

1. INTRODUCTION

Enormous literature is available on *Fagonia cretica*, a small wild spiny under-shrub found mostly in dry calcareous rocks and sandy soils throughout Pakistan. *Fagonia cretica* is member of the family *Zygophyllaceae*. Its medicinal value is well documented [2-3]. The plant tastes bitter and is usually used for the treatment of fever, dysentery, asthma, skin infection and liver troubles [2, 3, 5]. Its active ingredients are reported [1-3] and the effect of each ingredient, like bitter alkaloids – especially the Saponin-1 and Saponin-2, has been studied on various animals [4-10]; but, probably, no scientific study has ever been under taken on clinical grounds by a medical professional.

The role of *Fagonia cretica* in cancer treatment has long been discussed and the possible mode of its action has also been suggested in the literature. For example, Lam et al [11] clearly elucidated that “an aqueous extract of *Fagonia cretica* induces DNA damage, cell cycle arrest and apoptosis in breast cancer cells via POXO3a and p53expression. Following genotoxic stress, an intact DNA damage response (DDR) is necessary to eliminate lethal and tumorigenic mutations. The DDR is a network of molecular signaling events which control and coordinate DNA repair, cell cycle arrest and apoptosis”. Impairment in the DNA damage response represents a double-edged sword; on the one side loss of repair mechanisms can drive tumorigenesis and on the other can affect sensitivity to genotoxic chemotherapy [11]. “The tumor suppressor protein, i.e., p53, plays a pivotal role in regulating the cellular response to stress and damage signals. Several of the cell signaling pathways involved in
the DDR and cell differentiation converge with p53 and loss of p53 functionality is common in more than 50% of cancers. In response to stress signals, post-translational modifications of p53, such as phosphorylation, drive its nuclear translocation and subsequent target gene transcription. Normally, upon DNA damage, p53 is rapidly stabilized by the DNA damage sensor, ATM, via phosphorylation of serine-15 within the p53 N-terminus activation domain. Consequently, dissociation of the MDM2-p53 repressor complex prevents monoubiquitination of p53 and its degradation. This in turn increases p53 half-life and activates its transcriptional program”.

It was for the first time in 1976, perhaps, that we got interested in this herbal product, when a Hakim gave this product to a breast cancer patient (Fungating ductal; Fig. 1), in the Seyal Medical Center, Multan, Pakistan. The blood group of the patient was B-ve, and it was very difficult to arrange the supply of blood group after each course of chemotherapy. When she started using Fagonia cretica, we evinced good clinical improvement and there was no need of blood transfusion after each course of chemotherapy. Thereafter, we started using this herbal product in all sort of cancer patients and observed that it takes care of almost all the side effects of cytotoxic drugs without compromising the cytotoxic efficiency of the chemotherapy, but instead supplements the cytotoxic efficacy of the drugs. Similar observations were made in Thalassemia. This reported study is based on these observations.

Since long, biologists believed that they understood how genetic mutations cause the disease. But recent our work has revealed an important ‘twist in the tale’ and uncovered surprising, even counterintuitive, ways by which alterations in DNA not only can make people sick but also can alter the original parent sick gene to normal [11-14]. The classic views assumed that what are termed “silent” mutation were inconsequential to health, because such changes in DNA would not alter the composition of the proteins encoded by genes. Proteins function in virtually every process carried out by cells, from catalyzing biochemical reactions to recognizing foreign invaders. Hence, if a protein’s makeup ends up being correct, any small glitches in the process leading to its construction could not do body harm, but instead will provide a relief to the sick masses [15-16].

The high incidence of Thalassemia is related to selective advantage of the carrier state to malaria infection. Initially, Thalassemia or the sickle cell mutation apparently arose repeatedly in regions riddled with malaria during the late 15th century in Africa and the Middle East [13]. As a result these diseases are more common in the areas where malaria is endemic, like the Mediterranean region, through tropical countries including like Sub-Saharan Africa, the Middle East, Pakistan, India, South East Asia, and Indonesia [12, 13].

Thalassemias are classified according to their severity into major, intermediate, and minor forms. Thalassemia intermediate is characterized by anemia and splenomegaly though not of such severity as to require regular transfusion. Thalassemia minor is the symptomless carrier state. While these descriptive terms do not have a precise genetic meaning, they remain useful in clinical practice [14].

During the last couple of years it has become clear that Thalassemia is extremely heterogeneous and that its clinical picture can result from the interaction of many different genetic defects, all of which result from a reduced rate of production of one or more of the globin chain(s) of hemoglobin. Because Thalassemia occurs in populations in which structural hemoglobin carriers are common, it is not at all unusual for an individual to receive a Thalassemia gene from one parent and a gene for a structural hemoglobin variant from the other. These different interactions produce an extremely complex and clinically diverse series of genetic disorders, which range in severity from death in utero to extremely mild, symptomless, hypochromic anemia [14-16].

Genetics have discovered thousands of mutations responsible for the incidence of diseases in humans, but founder mutations stand apart [13]. The victims of genetic disorders die before reproducing, stopping the spread of the original mutant genes from reaching the future creations. But the founder mutations often spare their carriers and therefore can spread from the original founder to his or her descendents. Perhaps the best-known
Fig. 1 In 1977 a 56 year old lady with a Fungating Breast Cancer. She was refused surgery and radiotherapy because of the very big size of the tumor. She was given combination chemotherapy along with Crude Extract of *Fagonia cretica* She recovered completely and died in 2004 This picture was taken 3 months after the treatment with Casemia. Initially, the breast looked like a weeping cauliflower, thus picture was not taken as I could never believe such a fascinating response and eventually it healed completely.
example of a double-edged genetic mutation is the one responsible for Thalassemia. A single copy gene helps the carrier to survive malarial infection [13, 18-19]. But two copies doom the bearer to pain and short life. But during the past century there have been lot of improvement in the treatment of Thalassemia. With repeated regular transfusions and chelating therapy the individuals with beta Thalassemia Major can survive beyond the age of forty. Bone marrow transplant is another choice of treatment but it has its own limitations [20-23]. Our 20-year research in Thalassemia gives convincing information about the effectiveness of this wild thorny plant, i.e., *Fagonia cretica*, in changing the genetic pattern of this long inherited disease.

The effectiveness of *Fagonia cretica* in the treatment of Thalassemia was a chance occurrence about 20 years back, when a critically ill Thalassemia patient responded in a miraculous way. We gave this herbal preparation out of curiosity, with the belief that it probably acts at the molecular level. Ever since we have used this herbal medicine in Thalassemia patients and found quite satisfactory results (data not reported). It was therefore planned to conduct a scientific study on the subject.

2. MATERIAL AND METHODS

The reported study comprised of two components. The first component is based on a case study of three patients. The second component has been designed as a usual treatment case controlled study based on the encouraging results of the first component.

**Case 1:** In 1992, a 12-year old girl suffering from Thalassemia major was having weekly transfusion besides having chelating agents. She was critically ill and was not responding to any treatment as the transfusions often resulted in severe blood reactions and the chelating agents caused a lot of distress. She had a lot of ascites with enlarged liver and spleen over and above 10 cm palpable below costal margins. She was given dried powder of *Fagonia cretica* whole flowering plant (in doses of 120 mg kg\(^{-1}\) body weight). She started exhibiting good clinical improvement in a couple of weeks with reduction in the size of spleen, liver and ascites. Her Hb F was 97.4% and Hb A2 2.6%, when she was first diagnosed Thalassemia Major at the age of six months. When she was almost free of the disease symptoms and was no longer transfusion-dependent for more than three months, her Hb A was 98%; Hb A2 was 1.6% and Hb F was 0.4 %.

**Case 2:** A seven years old boy was suffering Thalassemia major (Fig. 2-A) when first reported. His hemoglobin was 4.2 G, liver and spleen were 7 cm and 11 cm, respectively, palpable below costal margin; also, that there was a lot of ascites. He had been diagnosed with Thalassemia major when he was just six months old; at that age his hemoglobin was 6.3 Gm, Hb A 1.2%, Hb A2 2.4%, and Hb F 96.4%. He was given powdered *Fagonia cretica*. He showed good clinical improvement and after about one year (Fig. 2B) he was no more blood dependent. His Hb was 12.4 Gm, Hb A 87.6%, Hb F 10.2% and Hb A2 was 2.2%.

**Case 3:** A 13-year boy had been diagnosed with Thalassemia major when he was just three months old. Transfusions invariably caused severe blood reactions. His clinical condition gradually deteriorated. On the first visit his spleen was quite enlarged and palpable seven cm below the costal margin and liver five cm. There was a lot of ascites. The bony deformities were also evident (Fig. 3). His blood pictures on the first and subsequent visits are given in Table 1. His clinical improvement with this treatment was quite evident after about three and half months (Fig. 4) and more so after about six and a half months (Fig 5). During the course of treatment with *Fagonia cretica* he was not using other drugs. He is still using *Fagonia cretica* without any chelating agent or supportive medicines like folic acid or calcium supplements. Also, he never had blood transfusion after he started the herbal treatment. His Hb F dropped from 98.6% to 81.7% whereas Hb A increased from nil to 17.6% (Table1).

A usual case control study was planned to show the effects of the whole aerial parts of flowering plant of *Fagonia cretica* in all the three categories of Beta Thalassemia i.e., major; intermedia and minor. There were around 32 patients of Thalassemia major, six of intermediate and four of minor. The dropout rate was quite high in Thalassemia major
Table 1. Details about a patient of Beta Thalassemia Major (without transfusion).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1st diagnosed at the age of 3 months</th>
<th>1st Oct 2012</th>
<th>21st January 2013</th>
<th>15th April 2013</th>
<th>Normal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb</td>
<td>4.9</td>
<td>3.8</td>
<td>7.1</td>
<td>8.7</td>
<td>13.00-18.00</td>
</tr>
<tr>
<td>Total RBC</td>
<td>2.1</td>
<td>1.7</td>
<td>3.8</td>
<td>3.1</td>
<td>4.50-6.50</td>
</tr>
<tr>
<td>Hct</td>
<td>16.0</td>
<td>1.5</td>
<td>24.0</td>
<td>29.0</td>
<td>38.00-52.00</td>
</tr>
<tr>
<td>MCV</td>
<td>74.0</td>
<td>76</td>
<td>52.0</td>
<td>92.0</td>
<td>75.00-95.00</td>
</tr>
<tr>
<td>MCH</td>
<td>22.0</td>
<td>20</td>
<td>22.0</td>
<td>28.0</td>
<td>26.00-32.00</td>
</tr>
<tr>
<td>MCHC</td>
<td>30.0</td>
<td>22</td>
<td>28.0</td>
<td>30.0</td>
<td>30.00-35.00</td>
</tr>
<tr>
<td>Platelet Count</td>
<td>199.0</td>
<td>160</td>
<td>174.0</td>
<td>216.0</td>
<td>150.00-400.0</td>
</tr>
<tr>
<td>Nucleated RBCs</td>
<td>10.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

RBC MORPHOLOGY

- Hypochromia ++ +++ +++ +
- Microcytosis ++ +++ +++ +
- Macrocytosis ++ +++ +++ +
- Anisocytosis +++ +++ +++ +
- Poikilocytosis ++ +++ +++ +
- Schistocytes + ++ ++ +

HEMOGLOBIN ELECTROPHORESIS:

- Hb F:% 98.6 % 81.7% ≤ 1%
- Hb A2:% 1.4 % 0.7% < 3.5%
- Hb A: % ---- 17.6%

Spleen: Palpable below costal margin 7 cms Not Palpable
Liver: Palpable below costal margin 5 cms Not Palpable

3. RESULTS

The age of nine patients of Thalassemia in major varied from two to 13 years. Clinical investigations of the Thalassemia major patients included total hemoglobin content, size of the liver and spleen palpable below costal margin, and electrophoresis. These patients were advised to continue with the medicines like folic acid and chelating agents and avoid the food already prescribed by the physicians. The patients were monitored at weekly intervals by their attending physician. Finally, when the patients had shown good clinical improvement after about nine months and they were no more transfusion dependent, the electrophoresis was done to compare the results.

We applied the paired t-test to compare various determinants of blood tests and size of the liver and spleen. The total Hb significantly improved from 2.888-4.88 g (P<0.05). Mean hemoglobin content in patients before the treatment was 6.84 g, whereas after nine months it rose to 10.72 g. Similarly, before the treatment the average Hb A was 0.33% and
Table 2. Details about nine patients of Beta Thalassemia Major.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Age in months</th>
<th>Sex</th>
<th>Total Hb in Gm</th>
<th>Hb A %</th>
<th>Hb A2%</th>
<th>Hb F%</th>
<th>Liver Palpable in cms below costal margin</th>
<th>Spleen Palpable in cms below costal margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 male</td>
<td>8.2</td>
<td>12-14</td>
<td>96.5</td>
<td>2.8</td>
<td>1.6</td>
<td>97.2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>72 male</td>
<td>6.8</td>
<td>11.3</td>
<td>96.4</td>
<td>2.8</td>
<td>3.6</td>
<td>97.2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>60 female</td>
<td>7.2</td>
<td>9.4</td>
<td>98.4</td>
<td>1.2</td>
<td>1.4</td>
<td>98.8</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>15 male</td>
<td>5.2</td>
<td>8.5</td>
<td>92</td>
<td>1.6</td>
<td>2.2</td>
<td>98.4</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>156 male</td>
<td>7.8</td>
<td>11.6</td>
<td>93.5</td>
<td>1.2</td>
<td>2.3</td>
<td>95.8</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>51 male</td>
<td>9.2</td>
<td>11.2</td>
<td>94.6</td>
<td>3.6</td>
<td>2.6</td>
<td>96.4</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>24 male</td>
<td>7.19</td>
<td>11.29</td>
<td>97.7</td>
<td>2.1</td>
<td>2</td>
<td>97.9</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>36 male</td>
<td>6.2</td>
<td>12.4</td>
<td>96.8</td>
<td>3.2</td>
<td>2.7</td>
<td>96.8</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>156 male</td>
<td>3.8</td>
<td>8.7</td>
<td>17.6</td>
<td>1.4</td>
<td>0.7</td>
<td>98.6</td>
<td>6 ±</td>
</tr>
</tbody>
</table>

**Before**: At the time of first diagnosis  
**After**: 9 months after the treatment

*This patient never used transfusion during the course of treatment.

Table 3. Means and 95% confidence intervals.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Hb in Gm</td>
<td>6.84</td>
<td>10.72</td>
</tr>
<tr>
<td>Hb A %</td>
<td>0.33</td>
<td>87.05</td>
</tr>
<tr>
<td>Hb A2 %</td>
<td>2.21</td>
<td>2.12</td>
</tr>
<tr>
<td>Hb F %</td>
<td>97.45</td>
<td>10.82</td>
</tr>
<tr>
<td>Liver Cms below costal margin</td>
<td>2.44</td>
<td>0.00</td>
</tr>
<tr>
<td>Spleen Cms below costal margin</td>
<td>4.33</td>
<td>0.22</td>
</tr>
</tbody>
</table>

87.5% and the minimum improvement was above 66% (P<0.05), whereas reduction in Hb F was from 97.45% to 10.82% and minimum reduction was 66% (P<0.05). However, there is non-significant difference in Hb A2 before and after the treatment.

The size of liver was reduced significantly as the mean value for liver size before and after was 2.44 and 0.00 cm palpable below costal margin; the reduction was 1.03 to 3.84 (P<0.05; Table 3). Similarly, mean values for spleen were 4.33 cm before the treatment and 0.22 cm palpable below costal margin; reduction in spleen size was from 2.02 to 6.19 (P<0.05; Table 3).

The six patients in Thalassemia intermedia group were given the herbal treatment for about nine months. Their total hemoglobin, Hb F, Hb A2, Hb A, size of the spleen and liver palpable below costal margin were measured at start of the study and again at the end of study (Table 4). The hemoglobin significantly improved from 2.13 to 5.6 g (P<0.05). Mean values for hemoglobin before and after were 8.08 and 11.95, respectively. Mean values for Hb F before and after the treatment were 14.68 and 7.40.

The Hb F was reduced from 3.4 to 11.76 (P<0.05). Average value for Hb A2 were 4.31 and 3.31, before and after the treatment, respectively, and the reduction was 0.30–1.70 (P<0.05). The mean values for HbA were 82.00 and 89.58 and Hb A increased substantially from 2.0 to 13.6 (P<0.05). Average values for spleen before and after the treatment were 2.16 and 0.3 and the reduction in the size of spleen is 1.04 – 2.62 (P<0.05). The reduction in size of liver was insignificant as the mean size at the start of the study was 0.66 (Table 5).

The measurements for four patients of Thalassemia minor are given in Table 6. The first three patients used *Fagonia cretica* for three months only and the fourth patient, aged 28 years, for six months. The paired t-test was used to compare the means of different parameters. Mean values for hemoglobin before and after the treatment were 9.89 g and 11.5 g, respectively. The improvement in Hb was from 2.95 to 6.4 (P<0.05). Mean values of Hb A2 were 5.25 and 3.30, respectively, before and after; and the reduction in Hb A2 was from 0.13 to 3.77 (P<0.05). The average values for HbA
Table 4. Details about six patients of Intermedia.

<table>
<thead>
<tr>
<th>Patient</th>
<th>1-14MM</th>
<th>2-13MF</th>
<th>3-15MM</th>
<th>4-14MM</th>
<th>5-24MM</th>
<th>6-14MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb in Gm</td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>7.8</td>
<td>13.1</td>
<td>7.6</td>
<td>12.5</td>
<td>9.2</td>
<td>13.1</td>
<td>7.8</td>
</tr>
<tr>
<td>RBC MORPHOLOGY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypochromia</td>
<td>+++ -</td>
<td>+++ -</td>
<td>++ -</td>
<td>+++ -</td>
<td>+++ +</td>
<td>+++ +</td>
</tr>
<tr>
<td>Microcytes</td>
<td>++ +</td>
<td>+++ +</td>
<td>++ Few</td>
<td>++ Few</td>
<td>+++ +</td>
<td>+++ +</td>
</tr>
<tr>
<td>Macrocystosis</td>
<td>++ +</td>
<td>+++ Few</td>
<td>++ Few</td>
<td>+++ +</td>
<td>+++ +</td>
<td>+++ +</td>
</tr>
<tr>
<td>Anisocytosis</td>
<td>+++ +</td>
<td>+++ +</td>
<td>+++ +</td>
<td>+++ +</td>
<td>+++ +</td>
<td>+++ +</td>
</tr>
<tr>
<td>Poikilocytosis</td>
<td>++ +</td>
<td>+++ +</td>
<td>+++ +</td>
<td>+++ +</td>
<td>+++ +</td>
<td>+++ +</td>
</tr>
<tr>
<td>Schistocytes</td>
<td>+ -</td>
<td>++ +</td>
<td>++ +</td>
<td>++ +</td>
<td>++ +</td>
<td>++ +</td>
</tr>
<tr>
<td>NRBC</td>
<td>+ Few</td>
<td>- -</td>
<td>- +</td>
<td>- +</td>
<td>- +</td>
<td>- +</td>
</tr>
<tr>
<td>Spherocytes</td>
<td>+ -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>HEMOGLOBIN ELECTROPHORESIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hb F: %</td>
<td>19.6</td>
<td>4.2</td>
<td>11.6</td>
<td>5.3</td>
<td>12.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Hb A2: %</td>
<td>4.3</td>
<td>3.3</td>
<td>5.1</td>
<td>3.6</td>
<td>5.2</td>
<td>4.4</td>
</tr>
<tr>
<td>Hb A: %</td>
<td>76.1</td>
<td>92.5</td>
<td>83.3</td>
<td>91.1</td>
<td>88.0</td>
<td>88.1</td>
</tr>
<tr>
<td>Palpable below costal margin in cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spleen</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Liver</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 5. Means and 95% confidence intervals.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Before</th>
<th>After</th>
<th>Mean</th>
<th>95% confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB</td>
<td>8.08</td>
<td>11.95</td>
<td>2.13-5.60</td>
<td>significantly improved</td>
</tr>
<tr>
<td>HBF</td>
<td>14.68</td>
<td>7.10</td>
<td>3.40-11.78</td>
<td>significantly reduced</td>
</tr>
<tr>
<td>HBA2</td>
<td>4.31</td>
<td>3.31</td>
<td>0.29-1.70</td>
<td>non-significant, reduced</td>
</tr>
<tr>
<td>HBA</td>
<td>82</td>
<td>89.58</td>
<td>2.00-13.16</td>
<td>significantly improved</td>
</tr>
<tr>
<td>Spleen Cms below costal margin</td>
<td>2.16</td>
<td>0.33</td>
<td>1.04-2.62</td>
<td>significantly reduced</td>
</tr>
<tr>
<td>Liver Cms below costal margin</td>
<td>0.66</td>
<td>0</td>
<td>-0.41-1.75</td>
<td>significantly reduced</td>
</tr>
</tbody>
</table>

before and after were 94 and 96, respectively, and improvement in Hb A was up to 4.00 (P<0.05; Table 7).

4. DISCUSSION

Our more than 20-year experience with the use of *Fagonia cretica* has given a new hope in the treatment of Thalassemia. We observed that in almost all our patients, who regularly used the herbal medicine as recommended, the electrophoresis after about nine months of treatment evinced normal pattern. The size of the spleen and liver were reduced to normal and the ascites also disappeared. They exhibited impressive clinical improvement. In patient # 3, 5 and 6, hemoglobin used to drop below 10 g which necessitated fresh blood transfusion at about six weeks interval; therefore, we adopted the discipline of electrophoresis after six weeks of the transfusion, i.e., just before the next transfusion in all patients.
Table 6. Details about four patients of Thalassemia Minor.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1 Female</th>
<th>2 Female</th>
<th>3 Female</th>
<th>4 Male</th>
<th>5 Female</th>
<th>6 Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb in Gm</td>
<td>9.3</td>
<td>10.6</td>
<td>9.9</td>
<td>9.5</td>
<td>9.7</td>
<td>9.7</td>
</tr>
<tr>
<td>RBC MORPHOLOGY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypochromia</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Microcytes</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Macrocytes</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Anisocytosis</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Poikilocytosis</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Schistocytes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NRBC</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Spherocytes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HEMOGLOBIN ELECTROPHORESIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hb F:%</td>
<td>0.7%</td>
<td>0.7%</td>
<td>0.8%</td>
<td>0.8%</td>
<td>0.6%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Hb A2:%</td>
<td>5.2%</td>
<td>3.5%</td>
<td>5.0%</td>
<td>4.5%</td>
<td>5.1%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Hb A:%</td>
<td>94.1%</td>
<td>95.8%</td>
<td>94.2%</td>
<td>94.7%</td>
<td>94.3%</td>
<td>96.7%</td>
</tr>
</tbody>
</table>

*Patient 1-3 had treatment for only three months.

Table 7. Means and 95% confidence intervals.

<table>
<thead>
<tr>
<th>MINOR</th>
<th>Mean Before</th>
<th>Mean After</th>
<th>95% confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB</td>
<td>8.08</td>
<td>11.50</td>
<td>6.4-2.95 significantly improved</td>
</tr>
<tr>
<td>HBF</td>
<td>.67</td>
<td>.65</td>
<td>.05-.10 non-significant</td>
</tr>
<tr>
<td>HBA2</td>
<td>5.25</td>
<td>3.30</td>
<td>.18-3.77 significantly reduced</td>
</tr>
<tr>
<td>HBA</td>
<td>94</td>
<td>96</td>
<td>4.02 significantly improved</td>
</tr>
</tbody>
</table>

Amongst the first diseases to be studied at the genetic level, Thalassemia still remains a challenge for understanding the pathogenetic basis of inherited disorders as well as the molecular mechanism involved in the regulation of gene expression. Different studies have contributed to define the complex pathophysiological mechanisms underlying this disease and have made possible prevention programs based on large scale screening and prenatal diagnosis in populations at high risk [21, 23, 24]. Soon after gestation, the embryonic, fetal and later after birth the physiological changes in oxygen requirements are accompanied by the switching of globin gene expression [15, 16]. This process represents one of the most intriguing and studied regulatory mechanisms of gene expression which leads to progressive and sequential changes in the expression of embryonic, fetal and adult globin genes (Fig. 6) and thus allows synthesizing different types of hemoglobin tetramers. However, the detailed mechanisms that control this process are still not fully understood. Michela Grosso [20] gave a detailed elucidation of Thalassemia at molecular level.

Human hemoglobin synthesis requires two switches: from embryonic to fetal hemoglobin at 6 week of gestation and from fetal to adult production at birth (Fig. 6). The first genes to be expressed are those of the ζ-chain (α-like) and ε-chain (β-like), synthesized in the embryonic yolk sac until 4-5 weeks of gestation, which lead to the formation of Hb Gowers I (ζ2ε2) [26]. Then, with the change of the liver as the main erythropoietic compartment, synthesis of α and γ chains is activated. At this stage the embryonic Hb Gowers II (α2ε2) and Hb Portland
(ζ2γ2) are progressively and completely substituted by the fetal hemoglobin Hb F (α2γ2). Around birth, when the bone marrow becomes the main erythropoietic site, β-globin gene expression is activated to synthesize the adult Hb A (α2β2), which at birth is about 20% of total hemoglobin.

The switch from fetal to adult hemoglobin is completed within the first two years of life and leads to the pattern in which adult globin expression Hb A (α2β2) comprises about 97%, HbA2 (α2δ2) 2-3% and Hb F (α2γ2) less than 1% of total hemoglobin, respectively [15, 26]. The control of tissue and developmental expression of specific globin genes is exerted by physical interactions between different globin gene promoters and the Locus Control Region ‘LCR’ (LCR is a relatively large cluster region in the β-gene, encompassing -20Kb) through binding of both ubiquitous and erythroid-specific transacting factors. The sequential expression of different globin genes requires coordinated mechanisms of gene silencing and gene competition for the LCR sequences, as well as chromatin remodeling and complex chromosomal looping and tracking processes [15, 26].

The switching of the expression of β-globin genes is not only a fascinating and complex model used for studying regulation mechanisms of gene expression, but its full understanding could also have important therapeutic implications in the treatment of β-Thalassemia. Indeed, the clinical picture of this condition can improve in the presence of sufficiently high levels of ‘Hb F’ in β-Thalassemia syndromes, in fact, hereditary persistence or drug-mediated reactivation of γ-globin chain output may...
result in a reduction of the α and β globin chain imbalance, which represents the main pathogenetic factor influencing the severity of this condition [15, 26].

Locus Control Region persistent expression of fetal hemoglobin may be associated with specific genotypes or induced by appropriate drug treatments. In fact, fetal globin genes can be reactivated by demethylation of regulatory sequences generated by hydroxyurea or 5-azacytidine or histone deacetylation induced by treatment with short-chain fatty acids [15]. However, besides toxic side effects of these drugs, response to treatment is transient and highly variable. Thus a better understanding of the switching processes and regulatory mechanisms of the β-globin gene may provide a new therapeutic approach in the treatment of Thalassemia.

Our clinical data do not go deep down to the molecular level but our hematological and clinical observations strongly support that has an effect on the switching processes and regulatory mechanisms of the β-globin gene providing a powerful relationship of molecular basis of Thalassemia. Our results clearly elucidate the decrease in the fetal hemoglobin and also Hb A2 level, besides increasing the total globin concentration in the blood. A few patients suffering from Thalassemia major showed gradual drop in the hemoglobin level even though their electrophoresis reports were almost normal. The persistence of anemia could possibly be due to the clusters of inclusion bodies in the bone marrow causing poor erythropoiesis as discussed before [14-16].

Perhaps for the first time an observation is made that a medicine may change the genetic pattern. The results already discussed also indicate recovery of the distorted RBCs morphology, i.e., Microcytosis, Macrocytosis, Anisocytosis, Poikilocytosis, Schistocytosis, Nucleated RBC and Spherocytosis, in all the three groups of patients

Patients of Thalassemia intermedia showed gradual improvement in total hemoglobin without transfusion with marked improvement in their clinical condition with reduction in the size of the spleen. Similarly, the Thalassemia minor patients exhibited reduction in the Hb A2. Our observations strongly support that a detailed study should be conducted to show the influence of this herbal product at the molecular level and also elucidate exactly the clinical course of erythropoiesis in the bone marrow during the course of treatment in different patients.

Also, we need to work more aggressively to know the active constituent(s) of this herbal plant which are effective in the treatment of Thalassemia. A lot of work has already been done to dig out the active ingredients of Fagonia cretica. The chemical constituents are Triterpenoid Saponins: Saponin 1 and Saponin 11, besides it contains beta-sitosterol; ceryl-alcohol; chinovic acid; water soluble saponins, i.e., glucose rhamose; xylose; arabinose; fagogenine and lipids 0.3-1.14%: Campesterol; aglycone; fagonin; oleanolic acid; betulic acid, the later four are derived from the saponins fraction [1-3]. It is beyond the scope of this paper to discuss each chemical constituent of the herbal plant, but we do need to determine and isolate the active ingredients alone or in combination which are effective in all categories of Thalassemia.

5. ACKNOWLEDGEMENTS
This research was conducted and shared by Ayesha Marion Foundation in Dr A Q Khan Thalassemia Research Center. I am highly indebted to Dr. A.Q. Khan for his most sincere support and persuasive guidance for research on the subject.

6. REFERENCES


Statistical Analysis of Cloud Cover at Pakistan Coastal Regions

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Abstract: This study presents a descriptive statistical analysis of cloud cover using monthly data for Sindh and Makran coasts recorded by the Pakistan Meteorological Department from 1980 to 2004. For Sindh coast, we are considered the data for Karachi and for Makran, we have taken the case of Quetta. For this purpose, Exploratory Data Analysis (EDA) approach was utilized. Through this approach, analysis of the data illustrated variability in the behavior of the cloud dynamics for both the regions. The degree of variation in the computed parametric values at Karachi region was remarkable as compared to the Quetta region. Interpretations of the temporal character depict that the fluctuations in the cloud concentration of Quetta region is different from Karachi due to coastal location.

Keywords: Cloud, cloud cover, atmosphere, climatology, descriptive statistics, exploratory data analysis

1. INTRODUCTION

It has been noticed that the clouds manifest an important role to maintain life on the Earth’s biosphere. Moreover, cloud density, overall size, altitude, shapes, area and other microphysical properties have significant impact on lower altitude atmosphere. Because of their low altitude, where temperature is comparatively high, these clouds reflect long-wave radiation towards the upper space. On the other hand, higher altitude clouds are comparatively thin, reflect lesser incoming radiations, and create a warming effect with emission of a small amount of infrared radiations.

It has been observed that variations in the cloud cover certainly change the balance in Earth’s energy budget. Cloud climatology describes the diurnal, seasonal, and inter-annual variations. On an annual average basis, clouds coverage area is between 60–65% of the Earth. Normally it is considered that cirrus clouds contribute globally to a warming of the atmosphere due to their contribution to downward transfer of long wave radiation, like a greenhouse agent [1-5].

A systematic research work for each month’s data on cloud cover for Karachi and Quetta region for a relatively long period has never been reported. In the present work, a systematic study of the variability of cloud cover at Karachi and Quetta regions, using descriptive statistics and exploratory data analysis (EDA), has been carried out for the period 1980–1984. The significance of this study is enormous because cloud cover has an apparent effect on the temperature forecast and atmospheric circulation.

2. EFFECTS OF CLOUD COVER

Thick and continuous cloud cover forms a significant barrier to the penetration of solar radiation. How much radiation is actually reflected by clouds depends on the amount of cloud cover and its thickness. It also serves to retain much of the heat that would otherwise be lost from the earth by long-wave radiations. Earth-space transmissions...
propagate through two important atmospheric regions: the troposphere and the ionosphere. The troposphere contains most of the Earth’s weather effects in terms of clouds, e.g. rainfall and snow. The dual effects of the troposphere and the ionosphere can give rise to the communication signal attenuation caused by atmospheric gases, clouds, precipitation, sand and dust. Attenuation of radio wave signals by clouds is similar to the attenuation by rainfall droplets. Attenuation by clouds depends on their characteristics such as, type, thickness and coverage. The clouds affect the radio wave propagation by absorbing and scattering the wave: a process described by Rayleigh scattering. Transmission of solar radiation through cloud coverage is measure of its layers and density [6-8].

3. METHODOLOGY

The cloud cover data was obtained by Pakistan Meteorological Department, Government of Pakistan by in-situ observations recorded in accordance with the World Meteorological Organization (WMO) standards. This study comprised of data analysis for cloud cover of Exploratory Data Analysis (EDA). Histogram is one of the oldest and most frequently used tools of the data analyst for the investigation of the overall distribution of a sample. Skewed histograms are not symmetric and can be either positively or negatively skewed. When a histogram is either positively or negatively skewed, the mean and the standard deviation may not be the appropriate measures of the center and spread. Use the median as the measure of the center and the inter-quartile range as the measure of the spread [9-10].

A normal probability plot is a scatter plot that compares observed and theoretical values much in the same manner. On the vertical axis, we find percentile values for a theoretical normal distribution sharing the same mean and standard deviation as the empirical data. The actual data values appear on the horizontal axis. If the two distributions matched perfectly, plotted points would fall on a straight line with a slope of 1.0, a line rising from the origin at a 45° angle [11].

A probability plot indicates how the distributions differ from each other. In the literature there are two types of probability plots, P-P plots and Q-Q plots. These plots can be best explained as cumulative distribution functions (CDF). The P-P plot is a simple & informative method for drawing such a comparison. It is used to determine how well a specific distribution fits to the observed data. By using a univariate or bivariate scaling of multivariate data, a P-P plot can also be used for comparing two multivariate samples with each other [12, 13].

The attraction of using the mean is that it is a single summary measure which is easy to calculate and readily understood. The median is particularly attractive when the data set is skewed, when the observations tend to be concentrated at one end of the range of values. The most important measures of variability are range and modified ranges, mean deviation, standard deviation, variance and coefficient of variation. The measure of variability appropriate to a problem depends on which measure of central location is used. The standard deviation, mean deviation and variance would all be used in association with the mean, while the inter-quartile range would be used in association with the median [14, 15].

The difference between the third and first quartiles is called the inter-quartile range (IQR). In some sense, the standard deviation, the range and the inter-quartile range provide measures of spread of the sample. We can calculate the inter-quartile range

\[ \text{Inter-quartile Range} = q_3 - q_1 \]

Where \( q_3 \) is the 3rd quartile and \( q_1 \) is the 1st quartile [16].

It has been said that the coefficient of variation (CV) is the measure that describes the scatter of the distribution relative to the size of the estimated mean and the diversity of the data from normality. The coefficient of variation is a measure of relative dispersion. It is appropriate for comparing the variability within different data sets. It determines the stability and consistency of the data and is given by

\[ CV = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100 \]

It has been indicated that the extremely low value of the calculated CVs about 7.0% that
Cloud Cover at Pakistan Coastal Regions

confirms a good degree of normality. From the above analysis it is shown that the standard error of the mean, is a method used to estimate the standard deviation of a sampling distribution. The error in the mean computed from a sample set of measured values that result because all measured values contain errors.

The standard error of the mean is computed by:

\[
\text{Standard Error of Mean} = \frac{S}{\sqrt{n}}
\]

where \(S\) is the sample standard deviation and \(n\) is the number of observations of the sample [14, 17].

Since the mean is arrived at by using all the values being examined, it can be distorted by extreme values (or so-called outliers). For this reason it is often appropriate to calculate a trimmed mean. The trimmed mean gives a robust measure of central location which is therefore not affected by a few extreme values. Trimmed means are often very useful and many times are used with a smaller trimming percentage. The mean, median and the trimmed mean are measures of the middle of the sample. We can calculate trimmed mean by the following equation:

\[
\text{Trimmed Mean} = \frac{q_1 + 2q_2 + q_3}{4}
\]

Where \(q_1\) is the 1\(^{st}\) quartile, \(q_2\) is the 2\(^{nd}\) quartile and \(q_3\) is the 3\(^{rd}\) quartile [15-17].

Skewness is a measure of the degree of asymmetry of a distribution. When a distribution is symmetrical about the mean, it is equal to zero. A measure of skewness is defined by

\[
E [(X-\mu)^3] / \sigma^3
\]

4. RESULTS AND DISCUSSION

In this section the various parameters have been computed for this data at 1200 UTC during 1980 to 2004 for both the regions. Analyzing data with the use of descriptive approach show clear distinction between the behavior of data sets for both the regions. Table 1 exhibits comparison of descriptive parameters of monthly mean total cloud covers of Karachi and Quetta regions during 1980 to 2004. It is to be noted that, an “Okta” is a unit used in meteorology indicating the presence of clouds, ranging from 0 to 8 Oktas.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Parameter</th>
<th>*(A)</th>
<th>*(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Total No. of Observation</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>02</td>
<td>Mean</td>
<td>2.582</td>
<td>2.800</td>
</tr>
<tr>
<td>03</td>
<td>Median</td>
<td>2.150</td>
<td>2.890</td>
</tr>
<tr>
<td>04</td>
<td>Stand. Dev.</td>
<td>1.766</td>
<td>1.457</td>
</tr>
<tr>
<td>05</td>
<td>Variance</td>
<td>3.119</td>
<td>2.125</td>
</tr>
<tr>
<td>06</td>
<td>Quartile (Q1) 25%</td>
<td>1.300</td>
<td>1.600</td>
</tr>
<tr>
<td>07</td>
<td>Quartile (Q3) 75%</td>
<td>3.500</td>
<td>3.875</td>
</tr>
<tr>
<td>08</td>
<td>Range</td>
<td>7.500</td>
<td>7.900</td>
</tr>
<tr>
<td>09</td>
<td>Interquartile Range</td>
<td>2.200</td>
<td>2.275</td>
</tr>
<tr>
<td>10</td>
<td>Semi-interquartile Range</td>
<td>1.100</td>
<td>1.137</td>
</tr>
<tr>
<td>11</td>
<td>Minimas</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>12</td>
<td>Maximas</td>
<td>7.5</td>
<td>8.0</td>
</tr>
<tr>
<td>13</td>
<td>Coefficient of Variation</td>
<td>68.40</td>
<td>52.22</td>
</tr>
<tr>
<td>14</td>
<td>Standard Error Mean</td>
<td>0.102</td>
<td>0.084</td>
</tr>
<tr>
<td>15</td>
<td>Trim Mean</td>
<td>2.490</td>
<td>2.764</td>
</tr>
<tr>
<td>16</td>
<td>Skewness</td>
<td>0.82</td>
<td>0.20</td>
</tr>
</tbody>
</table>

The calculated value of mean of monthly total cloud cover during 1980 to 2004 at Karachi region is 2.582, which is smaller value than the calculated value of mean of Quetta region i.e., 2.800. The computed value of median of the monthly total cloud cover at Karachi region is 2.15, which is smaller value than the calculated value of median of Quetta region, i.e., 2.89. It is interesting that the calculated value of mean (2.80) and median (2.89) is approximately same for the monthly total cloud cover of Quetta region during 1980 to 2004, while Karachi region has different values of mean (2.58) and median (2.15). So the data of monthly total cloud cover of Quetta region has a symmetrical distribution.

The data set of cloud cover at Karachi region has a larger standard deviation, i.e., 1.766 than the data set of cloud cover at Quetta region, i.e., 1.457. Thus, the data set for Karachi region was less precise than the data set for Quetta region for symmetrical distribution. We calculated the variance of cloud cover for Karachi region which was 3.049 while the variance of cloud cover of Quetta region which was...
2.10. This also revealed that the data of cloud cover of Karachi region is more dispersed than the data of Quetta region.

It can be seen from Table 1 that the data set could be described as having either a mean of 2.58 and a standard deviation of 1.766 or a median of 2.15 and an interquartile range of 2.2 or semi-interquartile range of 1.1. This means that approximately 50% of the observations lie within the range $2.2 \pm 1.1$ of the data of cloud cover at Karachi region. The values of median and interquartile range at Karachi region were very close to each other.

The minimum value for monthly total cloud cover during 1980 to 2004 at Karachi region was zero, while the minimum for monthly total cloud cover during 1980 to 2004 at Quetta region was 0.1. Thus, during the 30-year period, there was no cloud cover during certain days of a few months at Karachi whereas Quetta region had a minimum 0.1 Okta value, which indicates that a minimum amount of cloud cover was always present there during the 1980 to 2004 period.

The calculated value of coefficient of variation of monthly total cloud cover during 1980 to 2004 at Karachi region is 68.4% while Quetta region has 52.22%, which clearly shows that the standard deviation is quite high relative to the mean and thus the data show considerable variation around the mean of monthly total cloud cover at Karachi region. The Standard Error of the Mean of monthly total cloud cover at Karachi region is 0.084 whereas Quetta region has 0.102, therefore the standard errors of Mean of both regions are nearly zero.

We have calculated the trimmed mean of monthly total cloud cover at Karachi region is 2.49 while calculated mean is 2.58. The results show that the distribution of the data is positively skewed as the mean is greater than the median. Trimming the mean removes the extreme values and in this case gives a value equal to the mean, so we can say that the data of Karachi region has no extreme values or outliers.

The value of skewness of cloud cover at Quetta region is 0.20 that is small as compared to the Skewness value (0.82) of cloud cover at Karachi region. Both skewness values are positive. The skewness of Quetta region is near to zero. For the descriptive parameters regarding cloud cover data (1980 – 2004) of Pakistan coastal zones (Karachi region and Quetta region) and the corresponding histogram, as pointed out in Fig. 1 and Fig. 2, respectively. The histogram illustrates that the data of cloud cover at Karachi region are skewed to the right or positively skewed. While the other histogram illustrates that the data of cloud cover at Quetta region are symmetric about the center but has a steeper slope than Karachi region of Fig. 1, with a higher peak for its central value.

The vertical axes represent the normal quartiles and the observed observations are given on the horizontal axes. The normal probability plot for cloud cover data during 1980 to 2004 of Karachi region and Quetta region are depicted in Fig. 3 and Fig. 4, respectively. Normal probability plot exhibits that the data is half Gaussian. The normal probability plot of Karachi region indicates that the distribution has shorter (lighter) tails than the normal distribution. On the other hand, the normal probability of Quetta region is normal which signify that the distribution is almost linear in nature. It is noticeable in the plot that there is minor bend at the ends, representing some departure from normality.

The P-P plots for cloud cover data during 1980 to 2004 of Karachi region and Quetta region are represented in Fig. 5 and Fig. 6, respectively. A graphical representation of P-P plot can help us to decide whether our data sets are following Normal distribution or not. The P-P plot of Quetta region is approximately linear, so it follows normal distribution. The P-P plot of Karachi region has an apparent variation as shown in the curve. The Q-Q plot of Karachi region exhibits half Gaussian as depicted in Fig. 7 while Quetta region illustrates almost half Gaussian with an outlier. The reason of this point will be investigated further.

Our data are illustrated in Fig. 7, and Fig. 8 that depict a set of data appears to come from a particular probability distribution or not. The illustration clarifies probability of each value of the depth of cloud cover in its calculated volume. It is apparent that the Q-Q plot of Karachi region is periodic in nature. It is clear that the data for Q-Q plot for the cloud cover at Quetta region are
Fig. 1 Cloud cover at Karachi region during 1980 to 2004.

Fig. 2 Cloud cover at Quetta region during 1980 to 2004.

Fig. 3 Normal probability plot of cloud cover at Karachi region during 1980 to 2004.

Fig. 4 Normal probability plot of cloud cover at Quetta region during 1980 to 2004.

Fig. 5 Probability-probability plot of cloud cover at Karachi region during 1980 to 2004.

Fig. 6 Probability-probability plot of cloud cover at Quetta region during 1980 to 2004.
normally distributed because almost all points lie on a straight line. We can see in the plot of Quetta region that there is slight curvature at the ends, indicating some departure from normality.

5. CONCLUSIONS
The monthly data of total cloud cover for Quetta region revealed a symmetrical distribution, showing almost a linear behavior. However, the total cloud cover data for Karachi region indicated considerable variation, compared with the Quetta region. Comparative analysis for the 1980–2004 period also revealed no cloud covers in Karachi region during the month of October 1987, whereas a minimum amount of cloud cover always existed in Quetta region during the 1980 to 2004 period. The standard error of mean of both regions was negligible. The distribution of the data was positively skewed as the mean was greater than the median. Skewness of the data was more for Karachi region than for Quetta region.

The data of cloud cover at Karachi region are skewed to the right or positively skewed, while the data of cloud cover at Quetta region are symmetric but has a reasonable slope than Karachi region. The normal probability plot of Karachi region indicates that the distribution has shorter (lighter) tails than the normal distribution, while the normal probability of Quetta region is normal which signify that the distribution is almost linear in nature. It is noticeable in the plot that there is minor bend at the ends, representing some departure from normality. The P-P plot of Quetta region is approximately linear. Therefore, it will be an appropriate thus admits normal distribution. The P-P plot of Karachi region has an apparent variation as shown in the curve. The Q-Q plot of Karachi region exhibits half Gaussian while Quetta region illustrates almost half Gaussian with an outlier. The reason of this point will be investigated further. The information attained by this analysis can be utilized for the researchers, personnel of Pakistan Meteorological Department, Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) and also in the flight operations by Civil Aviation Authority including Pakistan Air Force.

6. ACKNOWLEDGEMENTS
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Calculation of $\nu g_{(9/2)}^+$ Isomers in $^{65}$Ni, $^{67}$Zn, $^{69}$Ge and $^{71}$Se Nuclei

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Abstract: We have calculated the reduced transition probabilities $B(M2, 9/2^+ \rightarrow 5/2^-)$ of odd $^{65}$Ni, $^{67}$Zn, $^{69}$Ge, and $^{71}$Se nuclei with neutron number $N=37$. The theoretical calculations of the reduced transition probabilities are compared with the experimental values. The width of isomeric levels, mean-life of isomers, and Weisskopf hindrance factors of those nuclei were calculated. The systematic isomeric levels are plotted as a function of odd mass number and indicated that isomeric level decreases with an increase in the mass number.

Keywords: Reduced transition probabilities, isomeric levels, hindrance factors, width of isomeric levels

1. INTRODUCTION

Nuclear shell model has explained the nuclear isomers in the vicinity of the closed shells. It convinces that the quadrupole de-excitation of single particle is very important in this field. Particle’s transition is governed by the single particle when the nuclear excitation is due to only one nucleon [1]. Isomers which are the long-lived excited state of an atom’s nucleus usually belong to shell closure or magic number. The features of subshell closure in $^{68}$Ni with neutron number N=40 was established by Broda et al. [2]. A study of the excited states and their decay pattern for the odd-even and even-odd nuclei gives the information of nuclear structure for a single particle state.

In odd $^{65}$Ni to $^{71}$Se nuclei the neutron number is $N=37$, the atomic number is even from Z= 28 to 34. The M2 ($9/2^+$ to $5/2^-$) transitions of those nuclei were established due to $\nu g_{(9/2)}^+$ configuration [3-6]. Theoretically and experimentally, the M2 transitions of odd-even nucleus between $9/2^+$ and $5/2^-$ states were observed in odd As isotopes from A = 67-79 [7,8]. The calculation of odd-even Arsenic nuclei of $\pi g_{(9/2)}$ configuration raised the possibility to calculate the isomerism of even-odd nuclei $\nu g_{(9/2)}^+$ configuration such as $^{65}$Ni, $^{67}$Zn, $^{69}$Ge and $^{71}$Se. Moreover, the systematic mean lives, reduced transition probabilities, width of isomeric levels, and Weisskopf hindrance factors in odd $^{65}$Ni to $^{71}$Se nuclei are not investigated yet. It would give the good information about the strength of shell closure for N=40. It is very interesting to study systematically by theoretical calculations of $^{65}$Ni, $^{67}$Zn, $^{69}$Ge and $^{71}$Se nuclei in details.
2. MATERIALS AND METHODS

2.1 Reduced Transition Probability B(M2)

The reduced transition probabilities B(M2) are defined for the γ-ray transitions with certain multipolarity as follows,

\[ B(M2; I_i \rightarrow I_f) = 7.381 \times 10^{-8} E_\gamma^{-5} P_\gamma(M2; I_i \rightarrow I_f) \]  

(1)

\( E_\gamma \) is the energy of the γ-ray transition and \( P_\gamma(M2; I_i \rightarrow I_f) \) is the partial γ-ray transition probability of the level, which can be obtained from the total transition probability of the level,

\[ P_\gamma(M2) = \frac{P(\text{level})}{\tau(\text{level})} \]  

(2)

where \( \tau(\text{level}) \) is the mean life of the level.

2.2 Width of Isomeric Levels, \( \Gamma_\gamma \)

It can be calculated by,

\[ \frac{1}{\tau_\gamma} = \frac{\Gamma_\gamma}{\hbar} \]  

(3)

Where; \( \gamma = \text{mean life} \)

\[ \hbar = h/2; \, h \text{ is the Plank constant} \]

2.3 Mean-life Time, \( \tau_\gamma \)

Based on the radioactive relation, the half-life \( T_{1/2} \) that gives,

\[ T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda} = 0.693 \tau \]  

(4)

so, \( \tau_\gamma = \frac{T_{1/2}}{0.693} \)

where, \( T_{1/2} = \text{Half-life} \)

2.4 Weisskopf Hindrance Factor, \( F_w \)

\[ F_w = \frac{B(M2)_{\text{w}}}{B(M2)_{\text{theoretical}}} \]  

(5)

Where; \( B(M2)_{\text{w}} = 1.65 A^{2/3} \)

3. RESULTS AND DISCUSSION

Calculations of the reduced transition probabilities B(M2), isomeric levels, mean life, width of the isomeric levels of odd \( ^{65}\text{Ni} \) to \( ^{71}\text{Se} \) nuclei are presented in Table 1 [9]. The available experimental uncertainties are presented by first bracket in the Table 1.

3.1 Isomeric levels

Fig. 1 shows the isomeric levels plotted versus odd mass number of \( ^{65}\text{Ni} \) to \( ^{71}\text{Se} \) nuclei. It is shown that the isomeric level \( 9/2^+ \) of odd nuclei \( ^{65}\text{Ni} \) to \( ^{71}\text{Se} \) is decreasing with the increase of the mass number monotonically. The energy spectra of the N=37 isotones significantly decreases as the valance protons increases to the f-p shell in \( ^{65}\text{Ni}, ^{67}\text{Zn}, ^{69}\text{Ge}, \) and \( ^{71}\text{Se} \) nuclei.

3.2 Systematic reduced transition probabilities B(M2)

The reduced transition probabilities of the \( ^{65}\text{Ni}, ^{67}\text{Zn}, ^{69}\text{Ge}, \) and \( ^{71}\text{Se} \) nuclei were calculated according to equation (1) and showed that M2-type has been assigned between \( 9/2^+ \) to \( 5/2^- \) based on selection rules. Fig. 2 shows the comparison of B(M2) between the theoretical and experimental data. It is shown that the calculated and experimental reduced

---

Table 1. Properties of isomers of \( ^{65}\text{Ni}, ^{67}\text{Zn}, ^{69}\text{Ge}, \) and \( ^{71}\text{Se} \) nuclei.

<table>
<thead>
<tr>
<th>Nucl.</th>
<th>Isomeric levels ( g_{\gamma \gamma} ) (keV)</th>
<th>( T_{1/2,\text{exp}} ) (ns)</th>
<th>( T_{1/2,\text{exp}} ) (ns)</th>
<th>B(M2) ( w.u. ) (exp)</th>
<th>B(M2) ( w.u. ) (present)</th>
<th>( \Gamma_\gamma ) (eV)</th>
<th>( F_w )</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( ^{65}\text{Ni} )</td>
<td>1017.01 (10)</td>
<td>25.6 (11)</td>
<td>36.94</td>
<td>0.069</td>
<td>178.66</td>
<td>14.59</td>
<td>[3]</td>
<td></td>
</tr>
<tr>
<td>( ^{67}\text{Zn} )</td>
<td>604.48 (50)</td>
<td>333</td>
<td>480.52</td>
<td>0.054</td>
<td>0.067</td>
<td>13.74</td>
<td>14.37</td>
<td>[4]</td>
</tr>
<tr>
<td>( ^{69}\text{Ge} )</td>
<td>397.94 (18)</td>
<td>2.81 (5)</td>
<td>4054.83</td>
<td>0.066 (1)</td>
<td>0.065</td>
<td>1.63</td>
<td>15.28</td>
<td>[5]</td>
</tr>
<tr>
<td>( ^{71}\text{Se} )</td>
<td>260.48 (10)</td>
<td>19.0 (5)</td>
<td>27417.03</td>
<td>0.076 (2)</td>
<td>0.079</td>
<td>0.24</td>
<td>12.66</td>
<td>[6]</td>
</tr>
</tbody>
</table>
Calculation of $\nu_{g(9/2)^+}$ Isomers in $^{65}$Ni, $^{67}$Zn, $^{69}$Ge, $^{71}$Se Nuclei

Fig. 1. Isomeric levels (9/2+) versus odd mass number of $^{65}$Ni to $^{71}$Se nuclei for $N=37$ isotones.

Fig. 2. B(M2) values in W.u. versus odd mass number of $^{65}$Ni to $^{71}$Se nuclei.
transition probabilities B(M2) as a function of mass number are close to each other except $^{67}$Zn. It is essential to note that $\nu_{g(9/2)}^+ \to \nu_{f(5/2)}^-$ state in $^{67}$Zn is not pure B(M2) transition. There is a mixing ratio with B(E3) transition according to selection rules. The experimental values of B(M2) is 0.05% compared to B(E3) values. B(E3) reduced transition probabilities are dominated in $^{67}$Ni. The uncertainty of experimental data of $^{67}$Ni is not found in the literature [4]. There is a discrepancy of calculated and experimental B(M2) values in $^{67}$Zn which is due to mixing ratio. The theoretical calculations of the reduced transition probabilities B(M2) are in good agreement with the previous experimental results.

3.3 Width of isomeric levels ($\Gamma$)

The width of the isomeric levels are calculated from equation (3). The width indicates the thickness of the gamma rays produced from the transition. The values of the widths of the isomeric levels are 178.66, 13.74, 1.63 and 0.24 eV of $^{65}$Ni, $^{67}$Zn, $^{69}$Ge, and $^{71}$Se nuclei respectively. It indicates that the width of the gamma rays decreases with the increase of the neutrons of $^{65}$Ni, $^{67}$Zn, $^{69}$Ge, and $^{71}$Se isomers.

3.4 Weisskopf Hindrance Factor, Fw

The Weisskopf Hindrance Factor, Fw of $^{65}$Ni, $^{67}$Zn, $^{69}$Ge, and $^{71}$Se were calculated according to equation (4). The values of the hindrance factor are 14.59, 14.37, 15.28 and 12.66 of $^{65}$Ni, $^{67}$Zn, $^{69}$Ge, and $^{71}$Se respectively. The maximum value of hindrance factor is 15.28 for $^{67}$Zn.

4. CONCLUSIONS

The systematic mean life, reduced transition probabilities B(M2), width of isomeric level, and Weisskopf hindrance factor are calculated in odd $^{65}$Ni to $^{71}$Se isomers. The theoretical calculations of the reduced transition probabilities B(M2) are in good agreement with the previous experimental results.

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Borel Summability for Fractional Differential Equation in the Unit Disk

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Abstract: In this article, we consider some classes of nonlinear fractional differential equations with singularity take the form

\[ t^\alpha \frac{\partial^\alpha u(t,z)}{\partial t^\alpha} = F(t,z,u,\frac{\partial u}{\partial z}), \quad 0 < \alpha < 1, \]

where \( t \in J := [0,1] \) and \( z \in U := \{ z \in \mathbb{C} : |z| < 1 \} \). Our purpose is to establish a result similar to the k-summability known in the case of singular ordinary differential equations. It's shown that, under some conditions, all formal solutions are Borel summable or k-summable with respect to \( z \in U \) in all directions except at most a countable number.

Keywords: Fractional calculus; Fractional differential equation; Holomorphic solution; Unit disk; Riemann-Liouville operators; Nonlinear; Singular fractional differential equation; Borel summable.

AMS Mathematics Subject Classification: 30C25

1. INTRODUCTION

Since the last decade, fractional calculus is a rapidly growing subject of interest for physicists and mathematicians. The reason for this is that problems may be discussed in a much more stringent and elegant way than using traditional methods. Fractional differential equations have emerged as a new branch of applied mathematics which has been used for many mathematical models in science and engineering. In fact, fractional differential equations are considered as an alternative model to nonlinear differential equations. The class of fractional differential equations of various types plays important roles and tools not only in mathematics but also in physics, control systems, dynamical systems and engineering to create the mathematical modeling of many physical phenomena. Naturally, such equations required to be solved.

The present paper deals with a nonlinear singular fractional differential equation [1,2], in sense of the Riemann-Liouville operators, in the analytic category. The Riemann-Liouville fractional derivative could hardly pose the physical interpretation of the initial conditions required for the initial value problems involving fractional differential equations. One of the most frequently used tools in the theory of fractional calculus is furnished by the Riemann-Liouville operators [3].

Definition 1.1. The fractional (arbitrary) order integral of the function \( f \) of order \( \alpha > 0 \) is defined by

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When \( a = 0 \), we write \( I^\alpha_a f(t) = f(t) \ast \phi_{\alpha}(t) \),
where \((*)\) denoted the convolution product,
\[
\phi_{\alpha}(t) = \frac{t^{\alpha-1}}{\Gamma(\alpha)}, \quad t > 0
\]
and \( \phi_{\alpha}(t) = 0, t \leq 0 \) and \( \phi_{\alpha} \to \delta(t) \) as \( \alpha \to 0 \)
where \( \delta(t) \) is the delta function.

**Definition 1.2.** The fractional (arbitrary) order derivative of the function \( f \) of order \( 0 < \alpha < 1 \) is
defined by
\[
D^\alpha_t f(t) = \frac{d}{dt} \int_t^\infty \frac{(t-\tau)^{-\alpha}}{\Gamma(1-\alpha)} f(\tau)d\tau = \frac{d}{dt} I^{1-\alpha}_a f(t).
\]

**Remark 1.1.** From Definition 1.1 and Definition 1.2, we have
\[
D^\alpha_t t^\mu = \frac{\Gamma(\mu+1)}{\Gamma(\mu-\alpha+1)} t^{\mu-\alpha}, \quad \mu > -1; 0 < \alpha < 1
\]
and
\[
I^\alpha_t t^\mu = \frac{\Gamma(\mu+1)}{\Gamma(\mu+\alpha+1)} t^{\mu+\alpha}, \quad \mu > -1; \alpha > 0.
\]

In the present work we consider the summability of fractional differential equation takes the form
\[
t^\alpha \frac{\partial}{\partial t^\alpha} u(t, z) = F(t, z, u, \frac{\partial u}{\partial z}), \quad (1)
\]
subject to the initial condition \( u(0,0) = 0 \), where \( t \in J := [0,1], \ z \in U, \ u(t, z) \) is an unknown function and \( F(t, z, u, v) \) is a function with respect to the variables \((t, z, u, v) \in J \times U \times C^2\).

We need the following assumptions in the sequel:

**(H1)** \( F(t, z, u, v) \) is a holomorphic function defined in a neighborhood of the origin \((0,0,0,0) \in J \times U \times C^2\).

**(H2)** \( F(0,0,0,0) = 0 \) near \( z = 0 \).

Thus the function \( F(t, z, u, v) \) may be expressed in the form:

\[
F(t, z, u, v) = A(t)u + B(z)u + C(z)v + R_\alpha(t, z, u, v), \quad (2)
\]

where
\[
A(z) := \frac{\partial F}{\partial t}(0, z, 0, 0), \quad B(z) := \frac{\partial F}{\partial u}(0, z, 0, 0),
\]
\[
C(z) := \frac{\partial F}{\partial v}(0, z, 0, 0),
\]

and the degree of \( R_\alpha(t, z, u, v) \) with respect to \((t, z, u, v) \) is greater than or equal to 2.

**(H3)** \( C(z) := z^2 c(z), \quad c := c(0) \neq 0.\)

**(H4)** Denotes \( b := B(0) \) such that
\[
b \neq \frac{\Gamma(k+1)}{\Gamma(k+1-\alpha)}, \quad \forall k \in N^*.
\]

**2. PRELIMINARIES**

In the section, we give out some denotations and preparations such as definitions and lemmas.

**Definition 2.1.** The majorant relations described as: if \( a(x) = \sum a_i x^i \) and \( A(x) = \sum A_i x^i \), then we say that \( a(x) \leq A(x) \) if and only if \( |a_i| \leq |A_i| \) for each \( i \).

**Definition 2.2.** [4] Let \( C[[t; z]] \) be the formal power series of \( t, z \) and \( C[t; z] \) be the convergent formal power series in some polydisc with positive radius. For a formal power series
\[
u(t, z) = \sum_{m \geq 0, n \geq 0} u_{mn} t^m z^{n+1}, \quad (t \in J, z \in U)
\]
then the formal Borel transform order \( k \) in \( z \) is
\[
B_k(u)(t, z) = \sum_{m \geq 0, n \geq 0} \frac{u_{mn}}{\Gamma((1+n)/k)} z^{n+1}.
\]

and
\[
C[t] [[z]]_k := \{u(t, z) \in C[[t; z]] \quad \text{and} \quad B_k(u)(t, z) \in C[t; z]\}, \quad (t \in J, z \in U).
\]

Moreover, we say that \( u(t, z) \in C[t], [[z]]_k \) \iff
there exists a constant \( d > 0 \) such that \( B_k(u)(t,z) \) is holomorphic in \( J \times \{ z \in U : |z| \leq d < 1 \} \).

**Definition 2.3.** For \( \delta, \theta \in \mathbb{R}, \theta > 0 \), we define sectorial domain by

\[
S(\delta, \theta, 1) = \{ z \in U : |\arg(z) - \delta| < \frac{\theta}{2} \}.
\]

Here \( \delta, \theta \) are called the direction and opening angle of the sectorial domain \( S(\delta, \theta) \), respectively. Note that the radius is equal to 1 ( \( |z| < 1 \)). A sectorial domain \( S' \) is called a proper subsector of \( S(\delta, \theta) \) if its closure is contained in \( S(\delta, \theta) \cup \{0\} \).

**Definition 2.4.** Let \( u(t,z) \) be analytic on \( J \times S(\delta, \theta) \). Then \( u(t,z) \in C[t][[z]]_k \) is called a Gevery asymptotic expansion order \( k \) of \( u(t,z) \) as \( z \to 0 \in S(\delta, \theta) \), if for any proper subsector \( S' \) of \( S(\delta, \theta) \) (with sufficiently small radius), there exist positive constants \( K_1, K_2 \) and \( 0 < r \leq 1 \) such that \( u(t,z) \in C[t][[z]]_k \) and

\[
\sup_{n,r} |u(t,z) - \sum_{n=0}^{N-1} u_n(t)z^n| \leq K_1K_2^N N^{1/k} |z|^N,
\]

\( z \in S', N = 1, 2, 3, \ldots \).

This relation is denoted by

\[
u(t,z) \approx_k u(t,z).
\]

Note that if \( \nu(t,z) \approx_k u(t,z) \) then \( u(t,z) \) is unique and it is called the \( k \)-sum of \( u(t,z) \) in the direction \( \delta \), and \( u(t,z) \) is said to be \( k \)-summable in the direction \( \delta \). Furthermore, \( 1 \)-summable is called Borel summable.

The \( k \)-summability of \( u(t,z) \in C[t][[z]]_k \) in a direction can be characterized as follows:

**Lemma 2.1.** A formal series \( u(t,z) \in C[t][[z]]_k \) is \( k \)-summable in \( S(\delta, \theta)(\theta > \pi k) \) if and only if \( B_k(u)(t,\zeta) \) is analytic in \( J \times S(\delta, \theta - \pi k) \) for all radius and satisfies a growth condition of exponential type

\[
\sup_{n \in J} |B_k(u)(t,\zeta)| \leq K_1 |\zeta |^{-k} e^{K_2 t^{1/k}},
\]

\( \zeta \in S' \subset S(\delta, \theta - \pi k) \)

for some positive constants \( K_1 \) and \( K_2 \).

**Definition 2.5.** [5] Let \( S = S(\delta, \theta) \) and \( \mu > 0 \). We denote by \( A_\mu \) the space of holomorphic functions \( f \) in \( S \) such that there exists \( C > 0 \) satisfying

\[
|f(\zeta)(1 + |\zeta|^2) e^{-\mu |\zeta|^2}| \leq C, \quad \forall \zeta \in S.
\]

For positive constant \( M < \infty \), we define the norm \( \| f \|_{A_\mu} \) by the formula

\[
\| f \|_{A_\mu} = M \sup_{\zeta \in S} |f(\zeta)(1 + |\zeta|^2) e^{-\mu |\zeta|^2}|.
\]

Note that \( A_\mu \| \|_{A_\mu} \) is a Banach algebra with respect to the convolution product. If \( \mu_2 > \mu_1, A_{\mu_1} \) can be considered as a sub-space of \( A_{\mu_2} \) and for any \( f \in A_{\mu_1} \),

\[
\| f \|_{A_{\mu_1}} \leq \| f \|_{A_{\mu_2}}.
\]

More properties can be found in the following results:

**Lemma 2.2.** [5,6] If \( f, g \in A_\mu \), then \( f \ast g \in A_\mu \) and \( \| f \ast g \|_{A_\mu} \leq \| f \|_{A_\mu} \| g \|_{A_\mu} \).

**Lemma 2.3.** Let \( \mu_2 > \mu_1 \) and \( f \in A_{\mu_1}, g \in A_{\mu_2} \), then

\[
\| f \ast g \|_{A_{\mu_2}} \leq e \frac{M^2 (\mu_2 - \mu_1)}{2}.
\]

**Proof.** From definition of convolution product we pose
Hence for arbitrary \( \mu_2 \leq \frac{1}{|\zeta|} \), \( |\zeta| < 1 \) we obtain the desired result.

3. EXISTENCE OF UNIQUE SOLUTION

We have the following result:

**Theorem 3.1.** Consider Eq.(1), the conditions (H1)-(H4) are valid, then the unique formal solution \( u(t,z) \) of Eq.(1) is a Borel summable in all directions except the direction which passes through any point of the set

\[
\frac{\Gamma(1)}{\Gamma(1-\alpha)} \frac{-b}{c}, \frac{\Gamma(2)}{\Gamma(2-\alpha)} \frac{-b}{c}, \frac{\Gamma(3)}{\Gamma(3-\alpha)} \frac{-b}{c}, \ldots
\]

\( 0 < \alpha < 1 \).

**Construction.** Equation (1) can be written as

\[
\gamma^\alpha \frac{\partial^\alpha}{\partial t^\alpha} u(t,z) = A(z)u + B(z)u + c(z)z^\alpha \frac{\partial u}{\partial z} + \sum_{m+n+p \geq 2} b_{m,n,p}(z)z^m u^n(z^\alpha \frac{\partial u}{\partial z}).
\]  

(4)

Now, we only need to consider the summability of the solution \( u(t,z) \) of Eq.(4), with \( u(t,0)=u(0,z)=0 \). Let \( B_i(u)(t,\zeta) := u(t,\zeta) \) be the Borel transform of \( u(t,z) \), then equation (4) is reduced into the following convolution product equation:

\[
[\gamma^\alpha \frac{\partial^\alpha}{\partial t^\alpha} -(b+c\zeta)]u = A(\zeta)u + B(\zeta)u + C(\zeta)u + F(\zeta).
\]  

(5)

If we set \( u(t,\zeta) = \sum_{n=0}^\infty u_l(\zeta) t^n \); then \( u_l \) satisfies the following equation

\[
\frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} \frac{-b-c\zeta}{\Gamma(l+1-\alpha)} u_l(\zeta) = A(\zeta)u_l(\zeta) + B(\zeta)u_l(\zeta) + C(\zeta)u_l(\zeta) + F_l(\zeta).
\]  

(6)

such that

\[
\frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} \frac{-b-c\zeta}{\Gamma(l+1-\alpha)} u_l(\zeta) \leq \frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} \frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} + |\zeta|.
\]  

(7)

By Lemma 2.1, to prove the k-summability of a formal solution, we only need to prove an estimate (3) of its Borel transform order k.

By Lemma 2.3 and the Banach fixed point theorem, we have

**Lemma 3.1.** Consider equation (6) and let \( \sigma > 0 \) as in (7). Let \( \mu_0 \) be a sufficiently large number such that \( B, C \in A_{\mu_0} \) and let

\( \mu = \mu_0 + 2e[BP \mu_0 + CPC \mu_0] \sigma^{-1} M^{-2} \). If \( F_i \in A_{\mu} \), then equation (6) has a unique solution \( u_l \in A_{\mu} \) and

\[
\| \frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} \frac{-b-c\zeta}{\Gamma(l+1-\alpha)} u_l \| \leq 2 \| F_i \|_\mu.
\]  

(8)

**Proof.** Consider \( \psi(\zeta) = \frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} \frac{-b-c\zeta}{\Gamma(l+1-\alpha)} u_l \) and the operator

\[
P : \psi \mapsto A(\zeta)* \frac{\psi(\zeta)}{\frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} \frac{-b-c}{\Gamma(l+1-\alpha)}} + B(\zeta)* \frac{\psi(\zeta)}{\frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} \frac{-b-c}{\Gamma(l+1-\alpha)}} + C(\zeta)* \frac{\psi(\zeta)}{\frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} \frac{-b-c}{\Gamma(l+1-\alpha)}} + F_i(\zeta).
\]
If functions $\psi, \phi \in A_\mu$, then
\[
\| \psi - \phi \|_\mu \leq \frac{e[\| B \|_{\mu_0} + \| C \|_{\mu_0}]\sigma^{-1}}{2eM^2[\| B \|_{\mu_0} + \| C \|_{\mu_0}]\sigma^{-1}M^{-2}} \| \psi - \phi \|_{\mu_0}^{-\frac{1}{2}} |v - \mu_0|_n.
\]
by Lemma 2.3 and the facts that
\[
\left| \frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} - b - c\zeta \right| \leq \sigma^{-1}
\]
and
\[
\left| - \frac{\zeta}{\Gamma(l+1)\Gamma(l+1-\alpha)} - b - c\zeta \right| \leq \sigma^{-1}.
\]
Hence, by the Banach fixed point theorem, the equation (6) has unique solution.

Furthermore,
\[
\| \frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} - b - c\zeta u_i \|_{\mu} \leq \frac{1}{2}
\]
\[
\| \frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} - b - c\zeta u_i \|_{\mu} + \| F_i \|_{\mu},
\]
which implies the inequality (8).

**Proof of Theorem 3.1.** Condition (H1) implies that there exists $\mu_0 > 0$ such that, in (5), all coefficient functions $A, B, C, A_{m,n,p}$ are in $A_{\mu_0}$ and that
\[
\sum_{m+n+p \geq 2} \| A_{m,n,p} \|_{\mu_0} t^mu^n v^p \in C\{t, u, v\}.
\]
In view of Lemma 3.1, by induction we have
\[
(\frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} - b - c\zeta)u_i \in A_{\mu}.
\]
Now by using the majorant series relationship we have, set
\[
U(t) := \sum_{i \geq 1} \| u_i \|_{\mu} t^i \quad \text{and} \quad W(t) := \sum_{i \geq 1} \left( \frac{\Gamma(l+1)}{\Gamma(l+1-\alpha)} - b - c\zeta \right)u_i \|_{\mu} t^i.
\]
Then by Lemma 2.2 and inequality (8) yields
\[
U(t) \ll \sigma^{-1} W(t) \ll 2\sigma^{-1} \| A \|_{\mu_0} + \sum_{m+n+p \geq 2} (\| B_{m,n,p} \| + \| A_{m,n,p} \|_{\mu_0}) \frac{\partial^m U}{\partial t^m}(\sigma^{-1}W)\frac{\partial^p W}{\partial t^p}.
\]
Consequently, we have
\[
U(t) \ll X(t) := 2\sigma^{-1} \| A \|_{\mu_0} + \sum_{m+n+p \geq 2} (\| B_{m,n,p} \| + \| A_{m,n,p} \|_{\mu_0}) \frac{\partial^m X}{\partial t^m}.
\]
\[
X(0) = 0.
\]
In virtue of implicit function theorem there is a constant $\rho$ and for all $t \in J$ such that
\[
\sup_{n \in J} |X(t)| \leq \rho \Rightarrow \sup_{n \in J} |U(t)| \leq \rho.
\]
Hence
\[
\sup_{n \in J} \left( \sum_{i \geq 1} \| u_i \|_{\mu} t^i \right) \leq \rho,
\]
which implies the estimate (3) holds and this completes the proof of Theorem 3.1.

**Example 3.1.** Assume the following equation
\[
\begin{cases}
\mathcal{L} u(t,z) := \frac{\partial^{0.5} u(t,z)}{\partial t^{0.5}} + 16z^2 \frac{\partial^2 u(t,z)}{\partial z^2} = \mathcal{O}(1.28) z^2 + (1+z)t^2, \quad t \in J := [0,1] \\
u(0,z) = 0, \text{ in a neighborhood of } z = 0.
\end{cases}
\]
where $u(t,z)$ is the unknown function. By putting
\[
u(t,z) = \mu(z)t + v(t,z) \quad (v(t,z) = \mathcal{O}(t^2))
\]
as a formal solution. Therefore, $\mu(z)$ satisfies
\[
\mu(z)^2 + 16z^2 \mu'(z) - 1 - z = 0.
\]
Now by assuming
\[
\mu(z) := q + \psi(z),
\]
where $q$ is a constant and $\psi(z) = \mathcal{O}(z)$ we obtain that $q = \pm 1$. Hence we impose the following equations:
\[
\begin{align*}
16z^2\psi'(z) + 2\psi(z) &= z - \psi^2(z), \quad q = 1 \\
\psi(0) &= 0, \\
16z^2\psi'(z) - 2\psi(z) &= z - \psi^2(z), \quad q = -1 \\
\psi(0) &= 0.
\end{align*}
\]

where the holomorphic solution \(\psi(z)\) exists uniquely and converges in a neighborhood of the origin and Borel summable.

4. ACKNOWLEDGEMENTS
The second author was fully supported by LRGS/TD/2011/UKM/ICT/03/02.

5. REFERENCES
Obituary

Prof. Riazuddin, FPAS

We are grieved to report the sad demise of an eminent scientist of Pakistan and a scientist of great international stature, Professor Riazuddin, has passed away on 9th September 2013 in Islamabad. He was elected Fellow of the Pakistan Academy of Sciences in 1976.

Prof. Riazuddin was awarded his BSc in 1951 and MA in Mathematics in 1953 by University of the Punjab, Lahore. In 1959 he was awarded PhD (Theoretical Particle Physics) by Cambridge University, UK. Since 1999, he was Director, National Centre for Physics, Quaid-i-Azam University campus, Islamabad. He was Professor, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, 1982-1998; Visiting Professor, University of Iowa, Iowa City, USA, 1981-1982; Visiting Professor, VPI and State University, Blacksburg, VA, USA, 1980-1981; Visiting Scientist, International Centre for Theoretical Physics, 1979-1980; Member (Technical), Pakistan Atomic Energy Commission, 1973-1976; and Principal Research Associate, Daresbury Nuclear Physics Laboratory, UK, 1972.

Dr. Riazuddin was a Visiting Professor, University of Maryland, College Park, Maryland, USA, 1970-72; Professor, University of Islamabad (now called Quaid-i-Azam University), 1966-1981; Research Associate, University of Pennsylvania, Philadelphia, 1965-1966; Visiting Senior Research Associate, University of Rochester, Rochester, New York, 1963-1965; and Reader in Physics, University of the Punjab, Lahore, 1959-1963. In 1968, Dr. Riazuddin was awarded Gold Medal in Physical Sciences for Scientists of less than 40 years of age by the Pakistan Academy of Sciences. In 1979, he was awarded Gold Medal jointly with Dr Fayyazuddin by the Pakistan Academy of Sciences for outstanding research work in Physical Sciences.

Professor Riazuddin was founder Director of Institute of Physics (later named as Department of Physics), Quaid-i-Azam University, Islamabad, at the time known as Islamabad University. The Institute was established in 1966 and was located then in Rawalpindi. Prof. Riazuddin, an eminent particle theorist, soon brought fame to the Institute; famous Physicists from abroad started visiting the Institute and making it a world class Institute of Particle Physics, the reputation which this Institute/Department enjoys till today.

Apart from his first class research and production of high quality students who are occupying eminent scientific positions, Prof. Riazuddin also made a variety of other important contributions to science in Pakistan. He was the Director of Nathiagali Summer College started in 1976, and remained so till his death. Also, his contributions to the nuclear security of Pakistan are very fundamental. He along with his younger colleagues made seminal contributions to the theoretical aspects of nuclear weapons of Pakistan. In recognition of these contributions, he was awarded Tamgha-i-Imtiaz in 1979, Sitara-i-Imtiaz in 1990 and Hilal-i-Imtiaz in 1999 by the Government of Pakistan.

In 2000, Prof. Riazuddin was elected as Fellow of the Third World Academy of Sciences as well as Fellow of the Islamic World Academy of
Obituary

During the same year, he won the 13th Khawarizmi International Award (First Prize) and the UNESCO Albert Einstein Gold Medal for Fundamental Science.

Prof. Riazuddin was a very polite person and a man of less word, but of great wisdom. He was extremely helpful to his students. Not only he will be greatly missed by his family and by his twin brother, Professor Riazuddin, with whom he collaborated in research and won twin awards, but he will also be greatly missed by his students, colleagues and fellow scientists in Pakistan and in the Islamic World.

Prof. Riazuddin’s demise has left us with a great gap in Physics of Pakistan which will not be filled for a long time. May God bless his soul with peace and tranquillity in heavens. Ameen.

Dr. N. M. Butt
Fellow, Pakistan Academy of Sciences
Obituary

Dr. Naeem Ahmad Khan, FPAS

It is with great sorrow to share that we have lost an eminent Fellow of the Pakistan Academy of Sciences, Dr. Naeem Ahmad Khan, who left us on 29th September 2013 for his eternal life in the world beyond us.

Dr. Khan was born on April 12, 1928 in Hoshiarpur (East Punjab). He did BA (Hons) from St. Stephen’s College, Delhi (1946); MA from Sind University (1950); MSc from Karachi University (1955); and PhD from University of Manchester (1958). He worked as a post-doctoral Fellow at the Atomic Energy Research Establishment, Harwell, England (1961-1962), and as a Research Fellow at the Bartol Research Foundation of the Franklin Institute, Philadelphia, USA (1964-1965).

He joined Indian Meteorological Department in 1946 and then opted to serve Pakistan and was transferred to Pakistan Meteorological Department. In 1961, he joined the Pakistan Atomic Energy Commission (PAEC) as Senior Scientific Officer, and was promoted to Principal Scientific Officer in 1967, Chief Scientific Officer in 1970 and Chief Scientist in December 1986. Dr. Khan was appointed as Head, Nuclear Physics Division at the Atomic Energy Centre, Lahore (1965), and was appointed Director of the Centre in 1967. In 1969, he became Director of the Pakistan Institute of Nuclear Science and Technology (PINSTECH). In 1970, he was appointed Director of Training and International Affairs of PAEC and then as Secretary, PAEC. After serving as Director Research at the PAEC Headquarters in Karachi, he returned to PINSTECH again as Director in 1977.

In 1984, Dr. Khan was appointed Chairman, Pakistan Council of Scientific and Industrial Research (PCSIR) where he made outstanding contributions by developing laboratories of PCSIR and in greatly enhancing the work culture by promoting scientists on merit. In 1989, he was appointed Advisor (Technical), COMSTECH, where he served for seven years.

Dr. Khan had more than 100 scientific publications, 69 scientific reports and 28 general articles, to his credit. He participated in 75 conferences and seminars and presented 37 papers. Besides teaching Meteorology at the PAF College, Risalpur, Dr. Khan taught post-graduate courses in Physics at Karachi and Punjab Universities. Five PAEC scientists earned their PhD from the University of Punjab under his supervision. Prof. Khan was a Founding Fellow of the Islamic Academy of Sciences (1986). Indeed, he was instrumental in founding the IAS in 1986 along with the late Dr. M. A. Kazi.

Dr. Naeem was a scientist of great integrity and a strong administrator with utmost devotion to his duties. He made seminal contributions to the development of PINSTECH. While working under him, as Head of the Nuclear Physics Division of PINSTECH (1977-1984), I observed that he used to negotiate tooth and nail with suppliers of the expensive equipments for the minimum possible price to save the Institute’s money. I was always so impressed by his honesty. Although he was a strong and honest administrator, he never damaged the career of the scientists working under him and never played any intrigues to manoeuvre higher positions. I did not find him having a grudge with
his colleagues. Dr. Khan was truly a legendary leader in science. He was, at the same time, a tough task master and a very kind boss.

Dr. Naeem Khan will be greatly missed by his colleagues and fellow scientists in Pakistan and in the Islamic World. May God bless his soul with peace and tranquillity in heavens. Ameen.

**Dr. N. M. Butt**  
Fellow, Pakistan Academy of Sciences
Proceedings of the Pakistan Academy of Sciences

Instructions for Authors

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