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Physical and Computational Sciences

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Pakistan Academy of Sciences

Bibliometric Analysis of Proceedings of the Paksitan Academy of Sciences: Part A from 2016 to 2022

Waseem Hassan*

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Since 2016, Scopus database is directly covering Proceedings of the Pakistan Academy of Sciences (PPAS): Part A. Till 28th April, 2022 it has published 190 research documents majorly comprising of articles (n=126), book chapters (n=42), conference papers (n=16) and reviews (n=6). PPAS-A publishes in the areas of computer science, materials science, physics and astronomy, engineering sciences, chemistry, statistics, mathematics, geography, and geology. The entire publication data was downloaded from Scopus and analyzed on R-Studio (Bibliometrix/ Biblioshiny). In all publication, 210 authors from 377 departments or institutes (or more precisely 192 universities) from 12 Asian, 11 European, 4 Middle East, 1 Oceanic (New Zealand), 1 North American (USA), and 3 African countries have contributed (Figure 1). The lists of all authors (with total publications (TP), total citations (TC), publications years, h-index, g-index and m-index), all universities (with TP) and countries (with TP) are provided in supplementary table 1. All publications (n=190) received 174 total citations with 6 h-index. Similarly for 2021 the Citescore, SJR and SNIP were found to be to 0.4, 0.161 and 0.367, respectively. In a short span of only six years, it has achieved considerable rankings in general computer science (193/226), general physics and astronomy (200/233) and general materials sciences (402/455). The success could be attributed to the entire editorial board, reviewers, and authors around the world.

Keywords: PPAS-A, Scopus, and Publications

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Supplementary Data

Table 1. List of all authors with total number of publications (NP), total citations (TC), h-index, g-index and m-index.

Table 2. List of all departments or institutes with total number of publications (NoP).

Table 3. List of all universities with total number of publications (NoP).

Table 4. List of all countries with total articles.

Figure 1. Country co-authorship network

Table 1. List of all authors with total number of publications (NP), total citations (TC), h-index, g-index and m-index.

S. No.	Element	NP	TC	h_index	g_index	m_index	PY_start
1.	ABBAS N	1	1	1	1	0.2	2018
2.	ABBAS W	1	2	1	1	0.167	2017
3.	ADNAN M	1	1	1	1	0.167	2017
4.	AFRADI FAK	1	1	1	1	0.167	2017
5.	AFZAL S	1	4	1	1	0.167	2017
6.	AGAH HR	1	2	1	1	0.25	2019
7.	AHMAD G	3	3	1	1	0.2	2018
8.	AHMAD I	2	7	2	2	0.286	2016
9.	AHMAD N	2	4	2	2	0.286	2016
10.	AHMAD S	1	3	1	1	0.2	2018
11.	AHMAD W	1	1	1	1	0.167	2017
12.	AHMED A	1	2	1	1	0.333	2020
13.	AHMED S	1	1	1	1	0.2	2018
14.	AHMED Z	1	1	1	1	0.333	2020
15.	AHSAN K	1	1	1	1	0.2	2018
16.	AJWAD A	1	1	1	1	0.2	2018
17.	AKHTAR N	1	2	1	1	0.167	2017
18.	AKHTAR R	1	1	1	1	0.25	2019
19.	AKRAM A	1	1	1	1	0.167	2017
20.	ALAM A	1	2	1	1	0.143	2016
21.	ALAM F	1	4	1	1	0.143	2016
22.	ALI J	1	1	1	1	0.333	2020
23.	ALI K	1	2	1	1	0.2	2018
24.	ALI M	2	3	1	1	0.143	2016
25.	ALI N	1	2	1	1	0.143	2016
26.	ALI R	1	2	1	1	0.2	2018
27.	ALI S	3	13	2	3	0.286	2016
28.	ALI U	1	1	1	1	0.333	2020
29.	AMIR A	1	1	1	1	0.167	2017
30.	AMIR M	1	1	1	1	0.5	2021
31.	ANSARI MRK	1	1	1	1	0.167	2017
32.	ANWAR S	1	9	1	1	0.167	2017

S. No.	Element	NP	TC	h_index	g_index	m_index	PY_start
33.	AOUF MK	1	2	1	1	0.5	2021
34.	AQDAS A	1	1	1	1	0.2	2018
35.	ARSHAD M	1	2	1	1	0.143	2016
36.	ASAD M	1	1	1	1	0.167	2017
37.	ASGHAR MN	1	3	1	1	0.167	2017
38.	ASHRAF M	5	8	2	2	0.4	2018
39.	ASHRAF SR	1	1	1	1	0.167	2017
40.	ASIF M	2	11	2	2	0.286	2016
41.	ATIQ S	1	1	1	1	0.167	2017
42.	AWAN MB	1	1	1	1	0.2	2018
43.	AYUB KHAN YUSUF ZAI M	1	1	1	1	0.167	2017
44.	AZEEM MI	1	2	1	1	0.143	2016
45.	AZIM S	1	1	1	1	0.25	2019
46.	BABAR MI	2	2	1	1	0.2	2018
47.	BADSHAH MA	1	1	1	1	0.2	2018
48.	BAHRI MAS	1	1	1	1	0.2	2018
49.	BAJWA IS	2	7	2	2	0.286	2016
50.	BASHIR S	2	2	1	1	0.167	2017
51.	BATOOL R	1	1	1	1	0.25	2019
52.	BHUTTA MMA	1	1	1	1	0.2	2018
53.	BIBI T	1	1	1	1	0.5	2021
54.	BUDISANTOSO ET	1	19	1	1	0.2	2018
55.	CHESNEAU C	1	1	1	1	0.5	2021
56.	DASTGEER F	1	7	1	1	0.167	2017
57.	DAYAN F	1	1	1	1	0.333	2020
58.	DURRANI FK	1	6	1	1	0.143	2016
59.	EL-ASHWAH RM	1	1	1	1	0.143	2016
60.	ERDUR S	1	2	1	1	0.167	2017
61.	FAROOQ M	1	1	1	1	0.2	2018
62.	FIRDOUS R	1	1	1	1	0.167	2017
63.	GELANI HE	1	7	1	1	0.167	2017
64.	HABIB M	1	2	1	1	0.143	2016
65.	HABIB T	1	1	1	1	0.25	2019
66.	HAFEEZ Y	2	3	1	1	0.143	2016
67.	HAMID B	1	1	1	1	0.143	2016
68.	HAMID NHA	1	2	1	1	0.25	2019
69.	HAQ I	1	1	1	1	0.2	2018
70.	HASEEBAH H	1	1	1	1	0.167	2017
71.	HASSAN AH	1	1	1	1	0.143	2016
72.	HAYAT M	1	1	1	1	0.25	2019
73.	HAYAT MK	2	3	1	1	0.167	2017
74.	HUSSAIN H	1	7	1	1	0.167	2017
75.	HUSSAIN M	2	2	1	1	0.143	2016

S. No.	Element	NP	TC	h_index	g_index	m_index	PY_start
76.	HUSSAIN MA	1	1	1	1	0.2	2018
77.	HUSSAIN T	2	3	1	1	0.167	2017
78.	IKHSAN MR	1	1	1	1	0.167	2017
79.	ILLAHI F	1	9	1	1	0.167	2017
80.	ILYAS M	1	2	1	1	0.143	2016
81.	ILYAS U	1	1	1	1	0.167	2017
82.	INAYATULLAH KHAN BABAR M	1	1	1	1	0.2	2018
83.	IQBAL K	1	8	1	1	0.167	2017
84.	IQBAL M	2	9	2	2	0.286	2016
85.	IQBAL MJ	1	1	1	1	0.143	2016
86.	IQBAL S	1	1	1	1	0.2	2018
87.	IRFAN M	1	1	1	1	0.2	2018
88.	IRSHAD N	1	2	1	1	0.143	2016
89.	JAAFAR O	1	1	1	1	0.2	2018
90.	JABEEN G	1	1	1	1	0.5	2021
91.	JABEEN S	1	4	1	1	0.167	2017
92.	JAMAL F	1	1	1	1	0.5	2021
93.	JAN B	1	1	1	1	0.167	2017
94.	JAN S	1	2	1	1	0.333	2020
95.	JAN T	4	5	1	1	0.143	2016
96.	JAVED A	1	1	1	1	0.2	2018
97.	JAVID K	1	1	1	1	0.25	2019
98.	KANWAL H	1	1	1	1	0.2	2018
99.	KAUSAR Z	1	6	1	1	0.143	2016
100.	KHALIL A	1	4	1	1	0.143	2016
101.	KHALIL FA	1	9	1	1	0.167	2017
102.	KHALIL MIK	1	2	1	1	0.333	2020
103.	KHALIL R	1	1	1	1	0.25	2019
104.	KHALIQ R	2	3	1	1	0.167	2017
105.	KHAN A	3	6	1	2	0.143	2016
106.	KHAN AR	1	1	1	1	0.25	2019
107.	KHAN AS	1	1	1	1	0.2	2018
108.	KHAN AW	2	5	1	2	0.143	2016
109.	KHAN F	1	2	1	1	0.2	2018
110.	KHAN FQ	2	5	2	2	0.4	2018
111.	KHAN I	2	11	2	2	0.286	2016
112.	KHAN M	1	1	1	1	0.167	2017
113.	KHAN MA	2	2	1	1	0.2	2018
114.	KHAN MI	3	6	1	2	0.143	2016
115.	KHAN RA	1	6	1	1	0.167	2017
116.	KHAN SU	7	21	3	3	0.429	2016
117.	KHITAB A	1	1	1	1	0.5	2021
118.	KHURSHID K	1	8	1	1	0.167	2017

S. No.	Element	NP	TC	h_index	g_index	m_index	PY_start
119.	KHUSRO S	3	13	2	3	0.286	2016
120.	KKAN A	1	1	1	1	0.143	2016
121.	MADIAN SM	1	2	1	1	0.5	2021
122.	MAJUMDAR AAK	1	2	1	1	0.143	2016
123.	MAQSOOD I	1	2	1	1	0.333	2020
124.	MAULUD KNA	1	1	1	1	0.2	2018
125.	MEHMOOD Z	1	2	1	1	0.167	2017
126.	MITRAYANA M	1	1	1	1	0.167	2017
127.	MOHSIN M	1	1	1	1	0.5	2021
128.	MOSTAFA AO	1	2	1	1	0.5	2021
129.	MUNIR M	2	3	1	1	0.143	2016
130.	MUSHTAQ M	2	7	2	2	0.333	2017
131.	MUYASAROH N	1	1	1	1	0.167	2017
132.	NADEEM A	1	1	1	1	0.2	2018
133.	NADEEM K	1	1	1	1	0.5	2021
134.	NAEEM AA	1	1	1	1	0.167	2017
135.	NAEEM B	1	2	1	1	0.2	2018
136.	NAEEM MA	2	7	2	2	0.286	2016
137.	NAEEM R	1	1	1	1	0.167	2017
138.	NAHRY N	1	2	1	1	0.25	2019
139.	NAJVIA N	1	1	1	1	0.2	2018
140.	NAQVI HJ	1	4	1	1	0.167	2017
141.	NASAR-U-MINALLAH M	1	2	1	1	0.2	2018
142.	NASEER H	1	2	1	1	0.2	2018
143.	NASIR M	1	7	1	1	0.167	2017
144.	NOOR S	1	1	1	1	0.25	2019
145.	QADIR MI	1	2	1	1	0.143	2016
146.	QAMAR A	1	1	1	1	0.2	2018
147.	QASIM I	2	5	1	2	0.143	2016
148.	QURESHI LA	1	1	1	1	0.2	2018
149.	RABBANI T	1	1	1	1	0.167	2017
150.	RAFIQ M	2	7	2	2	0.333	2017
151.	RAHIM S	1	1	1	1	0.5	2021
152.	RAHMAN F	1	1	1	1	0.2	2018
153.	RAHMAN MA	1	1	1	1	0.2	2018
154.	RAMIZA R	2	3	1	1	0.167	2017
155.	REHAN K	2	7	2	2	0.333	2017
156.	REN F	1	1	1	1	0.333	2020
157.	RIAZ I	1	4	1	1	0.167	2017
158.	SAEED AH	2	3	1	1	0.167	2017
159.	SAEED M	2	2	1	1	0.2	2018
160.	SAEED N	1	1	1	1	0.25	2019
161.	SAFDAR A	1	1	1	1	0.143	2016

S. No.	Element	NP	TC	h_index	g_index	m_index	PY_start
162.	SAHAR G	1	1	1	1	0.5	2021
163.	SAJJAD M	1	4	1	1	0.143	2016
164.	SALAM M	1	2	1	1	0.167	2017
165.	SALEEM A	1	1	1	1	0.167	2017
166.	SALEEM U	1	1	1	1	0.2	2018
167.	SALMAN KHAN M	1	1	1	1	0.167	2017
168.	SANA M	1	1	1	1	0.2	2018
169.	SARWAR F	1	1	1	1	0.25	2019
170.	SARWAR N	1	4	1	1	0.143	2016
171.	SHABBIR B	1	2	1	1	0.2	2018
172.	SHAH AA	2	3	1	1	0.333	2020
173.	SHAH MAA	1	1	1	1	0.5	2021
174.	SHAH MF	1	6	1	1	0.143	2016
175.	SHAH S	1	1	1	1	0.25	2019
176.	SHAH SK	1	1	1	1	0.143	2016
177.	SHAH SW	2	2	1	1	0.2	2018
178.	SHAMI TA	1	1	1	1	0.143	2016
179.	SHAMI UT	2	2	1	1	0.143	2016
180.	SHEHZAD K	1	2	1	1	0.167	2017
181.	SHERWANI RAK	1	1	1	1	0.5	2021
182.	SIDDIQUI NF	2	2	1	1	0.143	2016
183.	SIYAR M	1	1	1	1	0.2	2018
184.	SULTAN A	1	1	1	1	0.2	2018
185.	SULTANA G	1	1	1	1	0.2	2018
186.	SUSIANTINI E	1	19	1	1	0.2	2018
187.	SUTONDO T	1	19	1	1	0.2	2018
188.	SYARIP S	1	19	1	1	0.2	2018
189.	THOHIRIN A	1	2	1	1	0.25	2019
190.	TUNÇ C	1	2	1	1	0.167	2017
191.	UD DIN A	1	8	1	1	0.143	2016
192.	UL ABDIN Z	1	1	1	1	0.5	2021
193.	UL HAQ I	1	1	1	1	0.143	2016
194.	UL HAQ S	2	11	2	2	0.286	2016
195.	UL HASSAN R	1	1	1	1	0.143	2016
196.	ULLAH I	1	1	1	1	0.167	2017
197.	ULLAH K	2	2	1	1	0.143	2016
198.	ULLAH N	1	2	1	1	0.167	2017
199.	ULLAH S	1	2	1	1	0.143	2016
200.	UR RAHMAN S	1	4	1	1	0.143	2016
201.	WAHID MAA	1	1	1	1	0.2	2018
202.	WANG K	1	1	1	1	0.333	2020
203.	WASONO MAJ	1	1	1	1	0.167	2017
204.	XU Y	1	1	1	1	0.333	2020

S. No.	Element	NP	TC	h_index	g_index	m_index	PY_start
205.	YOUSAF J	1	2	1	1	0.167	2017
206.	ZAFAR MH	1	3	1	1	0.2	2018
207.	ZAFAR S	1	1	1	1	0.2	2018
208.	ZAFAR ZUA	3	8	2	2	0.333	2017
209.	ZAHRA N	1	1	1	1	0.2	2018
210.	ZULFIQAR A	1	1	1	1	0.5	2021

Table 2. List of all departments or institutes with total number of publications (NoP).

S. No.	Affiliations	Articles
1.	DEPARTMENT OF ELECTRICAL ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR PAKISTAN	7
2.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	5
3.	DEPARTMENT OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY UNIVERSITY OF MALAKAND DIR (L) PAKISTAN	3
4.	DEPARTMENT OF COMPUTER SCIENCE UNIVERSITY OF ENGINEERING AND TECHNOLOGY TAXILA PAKISTAN	3
5.	DEPARTMENT OF COMPUTER SCIENCE UNIVERSITY OF PESHAWAR PESHAWAR PAKISTAN	3
6.	DEPARTMENT OF STATISTICS HACETTEPE UNIVERSITY ANKARA TURKEY	3
7.	FACULTY OF ENGINEERING UNIVERSITY OF CENTRAL PUNJAB LAHORE PAKISTAN	3
8.	CENTRE FOR HIGH ENERGY PHYSICS UNIVERSITY OF THE PUNJAB LAHORE 54590 PAKISTAN	2
9.	DEPARTMENT OF AGRICULTURE SCIENCE POSTGRADUATE PROGRAM UNIVERSITY OF MUHAMMADIYAH MALANG JL RAYA TLOGOMAS NO 246 MALANG 65145 INDONESIA	2
10.	DEPARTMENT OF APPLIED PHYSICS UNIVERSITY OF KARACHI KARACHI PAKISTAN	2
11.	DEPARTMENT OF CIVIL ENGINEERING FACULTY OF ENGINEERING UNIVERSITAS INDONESIA INDONESIA	2
12.	DEPARTMENT OF CIVIL ENGINEERING UNIVERSITY OF MANAGEMENT AND TECHNOLOGY LAHORE PAKISTAN	2
13.	DEPARTMENT OF COMPUTER ENGINEERING AIR UNIVERSITY KAMRA CAMPUS PAKISTAN	2
14.	DEPARTMENT OF ECONOMICS GOVT S E COLLEGE BAHAWALPUR PAKISTAN	2
15.	DEPARTMENT OF ELECTRICAL ENGINEERING NATIONAL INSTITUTE OF TECHNOLOGY MALANG JL RAYA KARANGLO KM 2 MALANG 65143 INDONESIA	2
16.	DEPARTMENT OF ELECTRICAL ENGINEERING UNIVERSITY OF ENGINEERING & TECHNOLOGY PESHAWAR PAKISTAN	2
17.	DEPARTMENT OF ELECTRONICS UNIVERSITY OF PESHAWAR PESHAWAR PAKISTAN	2
18.	DEPARTMENT OF ENGINEERING PHYSICS AND MATHEMATICS FACULTY OF ENGINEERING AIN SHAMS UNIVERSITY CAIRO EGYPT	2

S. No.	Affiliations	Articles
19.	DEPARTMENT OF GEOGRAPHY GOVERNMENT COLLEGE UNIVERSITY LAHORE PAKISTAN	2
20.	DEPARTMENT OF GEOGRAPHY GOVT POSTGRADUATE COLLEGE GOJRA PAKISTAN	2
21.	DEPARTMENT OF GEOGRAPHY UNIVERSITY OF PESHAWAR PAKISTAN	2
22.	DEPARTMENT OF INDUSTRIAL ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR PAKISTAN	2
23.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF ENGINEERING AND TECHNOLOGY KSK CAMPUS LAHORE PAKISTAN	2
24.	DEPARTMENT OF PHYSICS GOVERNMENT COLLEGE UNIVERSITY FAISALABAD PAKISTAN	2
25.	DEPARTMENT OF PHYSICS THE UNIVERSITY OF LAHORE PAKISTAN	2
26.	DEPARTMENT OF STATISTICS GOVT S E COLLEGE BAHAWALPUR PAKISTAN	2
27.	DEPARTMENT OF STATISTICS THE ISLAMIA UNIVERSITY OF BAHAWALPUR BAHAWALPUR PAKISTAN	2
28.	ELECTRICAL ENGINEERING DEPARTMENT UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR PAKISTAN	2
29.	FACULTY OF INFORMATION TECHNOLOGY UNIVERSITY OF CENTRAL PUNJAB LAHORE PAKISTAN	2
30.	GEOGRAPHY DEPARTMENT UNIVERSITY OF PUNJAB LAHORE PAKISTAN	2
31.	GRADUATE SCHOOL OF RENEWABLE ENERGY DARMA PERSADA UNIVERSITY JL RADIN INTEN 2 PONDOK KELAPA EAST JAKARTA 13450 INDONESIA	2
32.	INSTITUTE OF ADVANCED MATERIALS BAHAUDDIN ZAKARIYA UNIVERSITY MULTAN 60800 PAKISTAN	2
33.	INSTITUTE OF CHEMISTRY UNIVERSITY OF TARTU RAVILA 14A TARTU 50411 ESTONIA	2
34.	INSTITUTE OF ENGINEERING AND COMPUTING SCIENCES UNIVERSITY OF SCIENCE AND TECHNOLOGY BANNU BANNUKP PAKISTAN	2
35.	INSTITUTE OF SPACE AND PLANETARY ASTROPHYSICS UNIVERSITY OF KARACHI KARACHI PAKISTAN	2
36.	INSTITUTE OF SPACE TECHNOLOGY KARACHI PAKISTAN	2
37.	MATHEMATICAL SCIENCES RESEARCH CENTRE FEDERAL URDU UNIVERSITY OF ARTS SCIENCES AND TECHNOLOGY KARACHI PAKISTAN	2
38.	PAKISTAN BUREAU OF STATISTICS SARGODHA PAKISTAN	2
39.	ABASYN UNIVERSITY ISLAMABAD PAKISTAN	1
40.	BASIC SCIENCES DEPARTMENT HIGHER INSTITUTE FOR ENGINEERING AND TECHNOLOGY NEW DAMICTTA EGYPT EGYPT	1
41.	BEIJING INSTITUTE OF TECHNOLOGY HAIDIAN DISTRICT MAIN CAMPUS BEIJING CHINA	1
42.	BEPPU-SHI OAZA TSURUMI 950-67 RENACE BEPPU 205 BEPPU-SHI 874-0842 JAPAN	1
43.	CENTER OF RENEWABLE ENERGY STUDIES DARMA PERSADA UNIVERSITY JAKARTA INDONESIA	1
44.	CENTER OF RENEWABLE ENERGY STUDIES DARMA PERSADA UNIVERSITY JL RADIN INTEN 2 PONDOK KELAPA EAST JAKARTA 13450 INDONESIA	1

S. No.	Affiliations	Articles
45.	CENTRE FOR HIGH ENERGY PHYSICS (CHEP) UNIVERSITY OF THE PUNJAB LAHORE 54590 PAKISTAN	1
46.	CENTRE FOR HIGH ENERGY PHYSICS UNIVERSITY OF THE PUNJAB LAHORE PAKISTAN	1
47.	CIVIL ENGINEERING DEPARTMENT UNIVERSITY OF MANAGEMENT AND TECHNOLOGY LAHORE PAKISTAN	1
48.	COLLEGE OF STATISTICAL AND ACTUARIAL SCIENCES UNIVERSITY OF THE PUNJAB LAHORE PAKISTAN	1
49.	COMSATS INSTITUTE OF INFORMATION TECHNOLOGY LAHORE PAKISTAN	1
50.	COMSATS UNIVERSITY ABBOTTABAD CAMPUS ABBOTTABAD PAKISTAN	1
51.	DALIAN UNIVERSITY OF TECHNOLOGY CHINA	1
52.	DEPARMENT OF CHEMICAL ENGINEERING QUAID-E-AWAM UNIVERSITY OF ENGINEERING SCIENCE & TECHNOLOGY NAWABSHAH PAKISTAN	1
53.	DEPARTEMENT OF GEOGRAPHY LAHORE COLLEGE FOR WOMEN UNIVERSITY LAHORE PAKISTAN	1
54.	DEPARTEMENT OF GEOGRAPHY UNIVERSITY OF THE PUNJAB LAHORE PAKISTAN	1
55.	DEPARTMENT DE FISICA I ENGINYERIA NUCLEAR UNIVERSITAT POLITE`CNICA DE CATALUNYA EDUARD MARISTANY 10 BARCELONA SPAIN	1
56.	DEPARTMENT FOOD SCIENCE COLLEGE OF TOURISM & HOTEL MANAGEMENT (COTHM) BAHAWALPUR PAKISTAN	1
57.	DEPARTMENT OF AGRICULTURE SCIENCE UNIVERSITY OF MUHAMMADIYAH MALANG JL RAYA TLOGOMAS NO 246 MALANG 65145 INDONESIA	1
58.	DEPARTMENT OF APPLIED PHYSICS UNIVERSITY OF KARACHI PAKISTAN	1
59.	DEPARTMENT OF APPLIED SCIENCES NATIONAL TEXTILE UNIVERSITY KARACHI CAMPUS PAKISTAN	1
60.	DEPARTMENT OF ARCHITECTURAL ENGINEERING AND DESIGN UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
61.	DEPARTMENT OF BASIC & APPLIED SCIENCES ARAB ACADEMY FOR SCIENCE TECHNOLOGY AND MARITIME TRANSPORT CAIRO EGYPT	1
62.	DEPARTMENT OF BASIC & APPLIED SCIENCES ARAB ACADEMY OF SCIENCE TECHNOLOGY AND MARITIME TRANSPORT CAIRO EGYPT	1
63.	DEPARTMENT OF BASIC SCIENCE FACULTY OF ENGINEERING THE BRITISH UNIVERSITY IN EGYPT CAIRO EGYPT	1
64.	DEPARTMENT OF BASIC SCIENCES AND RELATED STUDIES MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY JAMSHORO PAKISTAN	1
65.	DEPARTMENT OF BASIC SCIENCES DAWOOD UNIVERSITY OF ENGINEERING AND TECHNOLOGY KARACHI PAKISTAN	1
66.	DEPARTMENT OF BIOCHEMISTRY UNIVERSITY OF MALAKAND LOWER DIR18800 PAKISTAN	1
67.	DEPARTMENT OF BIOLOGICAL SCIENCE AND BIOTECHNOLOGY FACULTY OF SCIENCE THE HASHEMITE UNIVERSITY ZARQA 13133 JORDAN	1
68.	DEPARTMENT OF BIOTECHNOLOGY ENGINEERING KULLIYYAH OF ENGINEERING INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA P O BOX 10 KUALA LUMPUR 50728 MALAYSIA	1
69.	DEPARTMENT OF BOTANY UNIVERSITY OF THE PUNJAB LAHORE PAKISTAN	1

S. No.	Affiliations	Articles
70.	DEPARTMENT OF BUSINESS ADMINISTRATION SHAH ABDUL LATIF UNIVERSITY KHAIRPUR PAKISTAN	1
71.	DEPARTMENT OF BUSINESS ADMINISTRATION SHAHEED BENAZIR BHUTTO UNIVERSITY NAUSHAHRO FEROZE SINDH PAKISTAN	1
72.	DEPARTMENT OF BUSINESS ADMINISTRATION SHAHEED BENAZIR BHUTTO UNIVERSITY SANGHAR SINDH PAKISTAN	1
73.	DEPARTMENT OF BUSINESS ADMINISTRATION SHAHEED BENAZIR BHUTTO UNIVERSITY SINDH SANGHAR PAKISTAN	1
74.	DEPARTMENT OF CHEMICAL AND POLYMER ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY FAISALABAD CAMPUS LAHORE PAKISTAN	1
75.	DEPARTMENT OF CHEMICAL ENGINEERING BALOCHISTAN UNIVERSITY OF INFORMATION TECHNOLOGY ENGINEERING AND MANAGEMENT SCIENCES (BUITEMS) QUETTA PAKISTAN	1
76.	DEPARTMENT OF CHEMICAL ENGINEERING DUET KARACHI PAKISTAN	1
77.	DEPARTMENT OF CHEMICAL ENGINEERING FACULTY OF ENGINEERING UNIVERSITAS GADJAH MADA YOGYAKARTA INDONESIA	1
78.	DEPARTMENT OF CHEMICAL ENGINEERING MEHRAN UNIVERSITY OF ENGINEERING & TECHNOLOGY JAMSHORO PAKISTAN	1
79.	DEPARTMENT OF CHEMICAL ENGINEERING MNS UNIVERSITY OF ENGINEERING AND TECHNOLOGY MULTAN PAKISTAN	1
80.	DEPARTMENT OF CHEMICAL ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
81.	DEPARTMENT OF CHEMISTRY FACULTY OF MATHEMATICS AND NATURAL SCIENCES UNIVERSITAS SYIAH KUALA KOPELMA DARUSSALAM BANDA ACEH 23111 INDONESIA	1
82.	DEPARTMENT OF CITY AND REGIONAL PLANNING UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
83.	DEPARTMENT OF CIVIL ENGINEERING CHENAB COLLEGE OF ENGINEERING AND TECHNOLOGY GUJRANWALA PAKISTAN	1
84.	DEPARTMENT OF CIVIL ENGINEERING FACULTY OF ENGINEERING PANCASILA UNIVERSITY JALAN SRENGSENG SAWAH JAGAKARSA JAKARTA 12640 INDONESIA	1
85.	DEPARTMENT OF CIVIL ENGINEERING MIRPUR UNIVERSITY OF SCIENCE AND TECHNOLOGY MIRPUR AJ&K 10250 PAKISTAN	1
86.	DEPARTMENT OF CIVIL ENGINEERING PETRA CHRISTIAN UNIVERSITY SURABAYA 60236 INDONESIA	1
87.	DEPARTMENT OF CIVIL ENGINEERING UNIVERSITY OF ENGINEERING & TECHNOLOGY LAHORE PAKISTAN	1
88.	DEPARTMENT OF CIVIL ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
89.	DEPARTMENT OF CIVIL ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY TAXILA PAKISTAN	1
90.	DEPARTMENT OF CIVIL ENGINEERING UNIVERSITY OF LAHORE PAKISTAN	1
91.	DEPARTMENT OF CIVIL ENGINEERINNG THE UNIVERSITY OF FAISALABAD FAISALABAD PAKISTAN	1
92.	DEPARTMENT OF COMPUTER ENGINEERING INSTITUT TEKNOLOGI SEPULUH NOPEMBER JL TEKNIK KIMIA KEPUTIH SUKOLILO SURABAYA 60111 INDONESIA	1

S. No.	Affiliations	Articles
93.	DEPARTMENT OF COMPUTER SCIENCE - UBIT UNIVERSITY OF KARACHI PAKISTAN	1
94.	DEPARTMENT OF COMPUTER SCIENCE & INFORMATION TECHNOLOGY UNIVERSITY OF MALAKAND DIR (L) PAKISTAN	1
95.	DEPARTMENT OF COMPUTER SCIENCE & INFORMATION TECHNOLOGY UNIVERSITY OF MALAKAND LOWER DIR PAKISTAN	1
96.	DEPARTMENT OF COMPUTER SCIENCE & INFORMATION TECHNOLOGY UNIVERSITY OF MALAKAND MALAKAND KP PAKISTAN	1
97.	DEPARTMENT OF COMPUTER SCIENCE & IT GLIM INSTITUTE OF MODERN STUDIES BAHAWALPUR PAKISTAN	1
98.	DEPARTMENT OF COMPUTER SCIENCE & IT THE ISLAMIA UNIVERSITY OF BAHAWALPUR PAKISTAN	1
99.	DEPARTMENT OF COMPUTER SCIENCE & IT UNIVERSITY OF ENGINEERING & TECHNOLOGY PESHAWAR PAKISTAN	1
100.	DEPARTMENT OF COMPUTER SCIENCE & IT UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR PAKISTAN	1
101.	DEPARTMENT OF COMPUTER SCIENCE & IT UNIVERSITY OF MALAKAND CHAKDARA KP PAKISTAN	1
102.	DEPARTMENT OF COMPUTER SCIENCE & IT UNIVERSITY OF MALAKAND MALAKAND PAKISTAN	1
103.	DEPARTMENT OF COMPUTER SCIENCE & IT UNIVERSITY OF MALAKAND PAKISTAN	1
104.	DEPARTMENT OF COMPUTER SCIENCE & SOFTWARE TECHNOLOGY UNIVERSITY OF SWAT SWAT MINGORA PAKISTAN	1
105.	DEPARTMENT OF COMPUTER SCIENCE AIR UNIVERSITY ISLAMABAD AEROSPACE AND AVIATION CAMPUS KAMRA PAKISTAN	1
106.	DEPARTMENT OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY UNIVERSITY OF ENGINEERING & TECHNOLOGY PESHAWAR PAKISTAN	1
107.	DEPARTMENT OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY UNIVERSITY OF MALAKAND LOWER DIR PAKISTAN	1
108.	DEPARTMENT OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY UNIVERSITY OF MALAKAND MALAKAND PAKISTAN	1
109.	DEPARTMENT OF COMPUTER SCIENCE AND IT UNIVERSITY OF MALAKAND MALAKANDKP PAKISTAN	1
110.	DEPARTMENT OF COMPUTER SCIENCE BANNU UNIVERSITY OF SCIENCE AND TECHNOLOGY BANNU PAKISTAN	1
111.	DEPARTMENT OF COMPUTER SCIENCE BUITEMS TAKATU CAMPUS PAKISTAN	1
112.	DEPARTMENT OF COMPUTER SCIENCE COMSATS UNIVERSITY ISLAMABAD TAXILA CAMPUS PAKISTAN	1
113.	DEPARTMENT OF COMPUTER SCIENCE CONCORDIA COLLEGE BAHAWALPUR BAHAWALPUR PAKISTAN	1
114.	DEPARTMENT OF COMPUTER SCIENCE FEDERAL URDU UNIVERSITY OF ARTS SCIENCE & TECHNOLOGY KARACHI PAKISTAN	1
115.	DEPARTMENT OF COMPUTER SCIENCE FEDERAL URDU UNIVERSITY OF ARTS SCIENCE AND TECHNOLOGY PAKISTAN	1
116.	DEPARTMENT OF COMPUTER SCIENCE FORMAN CHRISTIAN COLLEGE UNIVERSITY LAHORE PAKISTAN	1

S. No.	Affiliations	Articles
117.	DEPARTMENT OF COMPUTER SCIENCE GOVERNMENT COLLEGE UNIVERSITY FAISALABAD PAKISTAN	1
118.	DEPARTMENT OF COMPUTER SCIENCE GOVT DEGREE COLLEGE FOR WOMEN AHMADPUR EAST BAHAWALPUR PAKISTAN	1
119.	DEPARTMENT OF COMPUTER SCIENCE IQRA UNIVERSITY ISLAMABAD PAKISTAN	1
120.	DEPARTMENT OF COMPUTER SCIENCE ISLAMIA COLLEGE UNIVERSITY PESHAWAR PESHAWAR PAKISTAN	1
121.	DEPARTMENT OF COMPUTER SCIENCE SHAHEED ZULFIQAR ALI BHUTTO INSTITUTE OF SCIENCE AND TECHNOLOGY ISLAMABAD CAMPUS ISLAMABAD PAKISTAN	1
122.	DEPARTMENT OF COMPUTER SCIENCE SINDH MADRASATUL ISLAM UNIVERSITY AIWAN-E-TIJARAT ROAD KARACHI 74000 PAKISTAN	1
123.	DEPARTMENT OF COMPUTER SCIENCE UNIVERSITY OF BALOCHISTAN QUETTA PAKISTAN	1
124.	DEPARTMENT OF COMPUTER SCIENCE UNIVERSITY OF ENGINEERING AND TECHNOLOGY TAXILA 47050 PAKISTAN	1
125.	DEPARTMENT OF COMPUTER SCIENCE UNIVERSITY OF KHARTOUM KHARTOUM SUDAN	1
126.	DEPARTMENT OF COMPUTER SCIENCE UNIVERSITY OF PESHAWAR PESHAWAR 25120 PAKISTAN	1
127.	DEPARTMENT OF COMPUTER SCIENCE UNIVERSITY OF SCIENCE & TECHNOLOGY BANNU KP PAKISTAN	1
128.	DEPARTMENT OF COMPUTER SCIENCE UNIVERSITY OF SWABI PAKISTAN	1
129.	DEPARTMENT OF COMPUTER SCIENCES & INFORMATION TECHNOLOGY THE ISLAMIA UNIVERSITY OF BAHAWALPUR BAHAWALPUR 63100 PAKISTAN	1
130.	DEPARTMENT OF COMPUTER SYSTEMS ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR PAKISTAN	1
131.	DEPARTMENT OF COMPUTING AND TECHNOLOGY IQRA UNIVERSITY PAKISTAN	1
132.	DEPARTMENT OF COMPUTING SHAHEED ZULFIKAR ALI BHUTTO INSTITUTE OF SCIENCE & TECHNOLOGY (SZABIST) ISLAMABAD PAKISTAN	1
133.	DEPARTMENT OF DISASTER MANAGEMENT UNIVERSITY OF BALUCHISTAN QUETTA PAKISTAN	1
134.	DEPARTMENT OF ECONOMICS GOVERNMENT SADIQ EGERTON COLLEGE BAHAWALPUR PAKISTAN	1
135.	DEPARTMENT OF ECONOMICS SCHOOL OF BUSINESS AND ECONOMICS UNIVERSITY OF MANAGEMENT AND TECHNOLOGY LAHORE PAKISTAN	1
136.	DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING SUNGKYUNKWAN UNIVERSITY SUWON SOUTH KOREA	1
137.	DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING UNIVERSITY OF ENGINEERING & TECHNOLOGY PESHAWAR PAKISTAN	1
138.	DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING UNIVERSITY OF MICHIGAN DEARBORN MI UNITED STATES	1
139.	DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING SUNGKYUNKWAN UNIVERSITY SUWON SOUTH KOREA	1

S. No.	Affiliations	Articles
140.	DEPARTMENT OF ELECTRICAL ENGINEERING AND INFORMATICS VOCATIONAL COLLEGE UNIVERSITAS GADJAH MADA YOGYAKARTA INDONESIA	1
141.	DEPARTMENT OF ELECTRICAL ENGINEERING AND TECHNOLOGY COLLEGE OF ENGINEERING AND TECHNOLOGY MSU-ILIGAN INSTITUTE OF TECHNOLOGY A BONIFACIO AVENUE ILIGAN PHILIPPINES	1
142.	DEPARTMENT OF ELECTRICAL ENGINEERING FACULTY OF ENGINEERING WIDYA MANDALA CATHOLIC UNIVERSITY JL KALISARI SELATAN NO 1 SURABAYA 60112 INDONESIA	1
143.	DEPARTMENT OF ELECTRICAL ENGINEERING INSTITUT TEKNOLOGI SEPULUH NOPEMBER JL TEKNIK KIMIA KEPUTIH SUKOLILO SURABAYA 60111 INDONESIA	1
144.	DEPARTMENT OF ELECTRICAL ENGINEERING INSTITUTE OF BUSINESS MANAGEMENT KARACHI PAKISTAN	1
145.	DEPARTMENT OF ELECTRICAL ENGINEERING INSTITUTE OF SPACE TECHNOLOGY ISLAMABAD 44000 PAKISTAN	1
146.	DEPARTMENT OF ELECTRICAL ENGINEERING KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY THUWAL MAKKAH SAUDI ARABIA	1
147.	DEPARTMENT OF ELECTRICAL ENGINEERING LAHORE UNIVERSITY OF MANAGEMENT SCIENCES SYED BABAR ALI SCHOOL OF SCIENCE AND ENGINEERING OPPOSITE SECTOR U DEFENCE HOUSING AUTHORITY LAHORE 54792 PAKISTAN	1
148.	DEPARTMENT OF ELECTRICAL ENGINEERING NATIONAL INSTITUTE OF TECHNOLOGY (ITN) MALANG 2ND CAMPUS ITN JL RAYA KARANGLO MALANG 65145 INDONESIA	1
149.	DEPARTMENT OF ELECTRICAL ENGINEERING NATIONAL INSTITUTE OF TECHNOLOGY (ITN) MALANG JL RAYA KARANGLO KM 2 EAST JAVA MALANG 65145 INDONESIA	1
150.	DEPARTMENT OF ELECTRICAL ENGINEERING NFC INSTITUTE OF ENGINEERING AND FERTILIZER RESEARCH FAISALABAD PAKISTAN	1
151.	DEPARTMENT OF ELECTRICAL ENGINEERING NUCES-FAST PESHAWAR CAMPUSKP PAKISTAN	1
152.	DEPARTMENT OF ELECTRICAL ENGINEERING PETRA CHRISTIAN UNIVERSITY JL SIWALANKERTO NO 121-131 SURABAYA 60236 INDONESIA	1
153.	DEPARTMENT OF ELECTRICAL ENGINEERING SEPULUH NOPEMBER INSTITUTE OF TECHNOLOGY (ITS) 1ST CAMPUS ITS KEPUTIH GEDUNG B C & AJ SUKOLILO SURABAYA 60111 INDONESIA	1
154.	DEPARTMENT OF ELECTRICAL ENGINEERING UET PESHAWAR PAKISTAN	1
155.	DEPARTMENT OF ELECTRICAL ENGINEERING UNIVERSITY OF ENGINEERING & TECHNOLOGY KSK CAMPUS LAHORE PAKISTAN	1
156.	DEPARTMENT OF ELECTRICAL ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE FAISALABAD CAMPUS FAISALABAD PAKISTAN	1
157.	DEPARTMENT OF ELECTRICAL ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
158.	DEPARTMENT OF ELECTRICAL ENGINEERING UNIVERSITY OF MANAGEMENT AND TECHNOLOGY (UMT) LAHORE 54700 PAKISTAN	1

S. No.	Affiliations	Articles
159.	DEPARTMENT OF ENGINEERING MANAGEMENT NUST COLLEGE OF ELECTRICAL AND MECHANICAL ENGINEERING RAWALPINDI PAKISTAN	1
160.	DEPARTMENT OF ENGINEERING PHYSICS INSTITUT TEKNOLOGI SEPULUH NOPEMBER KAMPUS ITS SUKOLILO SURABAYA 60111 INDONESIA	1
161.	DEPARTMENT OF ENVIRONMENTAL SCIENCE UNIVERSITY OF LATVIA JELGAVAS STREET 1 ROOM 302 RIGA LV-1004 LATVIA	1
162.	DEPARTMENT OF GEOGRAPHY GOVERNMENT POSTGRADUATE COLLEGE SAMANABAD FAISALABAD PAKISTAN	1
163.	DEPARTMENT OF GEOGRAPHY GOVT SADIQ EGERTON GRADUATE COLLEGE BAHAWALPUR PAKISTAN	1
164.	DEPARTMENT OF GEOGRAPHY UNIVERSITY OF KARACHI KARACHI PAKISTAN	1
165.	DEPARTMENT OF GEOGRAPHY UNIVERSITY OF THE PUNJAB QUAID-E-AZAM CAMPUS LAHORE PAKISTAN	1
166.	DEPARTMENT OF GEOLOGY FEDERAL URDU UNIVERSITY OF ARTS SCIENCE AND TECHNOLOGY KARACHI PAKISTAN	1
167.	DEPARTMENT OF INDUSTRIAL AND MANAGEMENT ENGINEERING HANKUK UNIVERSITY OF FOREIGN STUDIES 107 IMUN-RO DONGDAEMUN-GU SEOUL 130-791 SOUTH KOREA	1
168.	DEPARTMENT OF INDUSTRIAL ENGINEERING PETRA CHRISTIAN UNIVERSITY SURABAYA 60236 INDONESIA	1
169.	DEPARTMENT OF INDUSTRIAL ENGINEERING SCHOOL OF ENGINEERING UNIVERSITY OF MANAGEMENT AND TECHNOLOGY LAHORE PAKISTAN	1
170.	DEPARTMENT OF INDUSTRIAL ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY TAXILA PAKISTAN	1
171.	DEPARTMENT OF INFORMATICS PETRA CHRISTIAN UNIVERSITY SURABAYA 60236 INDONESIA	1
172.	DEPARTMENT OF INFORMATION SYSTEM NAROTAMA UNIVERSITY JL ARIEF RACHMAN HAKIM 51 SUKOLILO SURABAYA 60117 INDONESIA	1
173.	DEPARTMENT OF INFORMATION SYSTEMS COLLEGE OF COMPUTER ENGINEERING AND SCIENCES PRINCE SATTAM BIN ABDULAZIZ UNIVERSITY AL-KHARJ 11942 SAUDI ARABIA	1
174.	DEPARTMENT OF INFORMATION TECHNOLOGY FACULTY OF COMPUTING & INFORMATION TECHNOLOGY KING ABDULAZIZ UNIVERSITY JEDDAH SAUDI ARABIA	1
175.	DEPARTMENT OF INFORMATION TECHNOLOGY FACULTY OF COMPUTING AND IT KING ABDUL-AZIZ UNIVERSITY JEDDAH SAUDI ARABIA	1
176.	DEPARTMENT OF INFORMATION TECHNOLOGY KING ABDULAZIZ UNIVERSITY JEDDAH SAUDI ARABIA	1
177.	DEPARTMENT OF INFORMATION TECHNOLOGY SHAHEED BENAZIR BHUTTO UNIVERSITY SHAHEED BENAZIRABA SINDH PAKISTAN	1
178.	DEPARTMENT OF INFORMATION TECHNOLOGY THE ISLAMIA UNIVERSITY OF BAHAWALPUR BAHAWALPUR PAKISTAN	1
179.	DEPARTMENT OF INTERIOR ARCHITECTURE UNIVERSITAS CIPUTRA CITRALAND CBD BOULEVARD MADE SAMBIKEREP SURABAYA 67219 INDONESIA	1
180.	DEPARTMENT OF IT CONVERGENCE ENGINEERING KUMOH NATIONAL INSTITUTE OF TECHNOLOGY 61 DAEHAK-RO YANGHO-DONG GYEONGSANGBUK-DO GUMI 39177 SOUTH KOREA	1

S. No.	Affiliations	Articles
181.	DEPARTMENT OF LIVESTOCK AND POULTRY PRODUCTION BAHAUDDIN ZAKARIYA UNIVERSITY MULTAN PAKISTAN	1
182.	DEPARTMENT OF MANAGEMENT SCIENCES IQRA UNIVERSITY PAKISTAN	1
183.	DEPARTMENT OF MARINE ENGINEERING DARMA PERSADA UNIVERSITY JAKARTA INDONESIA	1
184.	DEPARTMENT OF MARINE SHIPBUILDING INSTITUTE OF POLYTECHNIC SURABAYA 1ST CAMPUS ITS KEPUTIH SUKOLILO JL TEKNIK KIMIA SURABAYA 60117 INDONESIA	1
185.	DEPARTMENT OF MATHEMATICS AND STATISTICS QUAID-E-AWAM UNIVERSITY OF ENGINEERING SCIENCE & TECHNOLOGY NAWABSHAH SINDH PAKISTAN	1
186.	DEPARTMENT OF MATHEMATICS AND STATISTICS UNIVERSITY OF LAHORE LAHORE PAKISTAN	1
187.	DEPARTMENT OF MATHEMATICS COLLEGE OF SCIENCE AL-MUSTANSIRIYAH UNIVERSITY BAGHDAD IRAQ	1
188.	DEPARTMENT OF MATHEMATICS COMSATS INSTITUTE OF INFORMATION & TECHNOLOGY SAHIWAL CAMPUS PAKISTAN	1
189.	DEPARTMENT OF MATHEMATICS FACULTY OF SCIENCE AIN SHAMS UNIVERSITY ABBASSIA CAIRO EGYPT	1
190.	DEPARTMENT OF MATHEMATICS FACULTY OF SCIENCE AIN SHAMS UNIVERSITY CAIRO EGYPT	1
191.	DEPARTMENT OF MATHEMATICS FACULTY OF SCIENCE DAMIETTA UNIVERSITY NEW DAMIETTA 34517 EGYPT	1
192.	DEPARTMENT OF MATHEMATICS FACULTY OF SCIENCE DELTA STATE UNIVERSITY P M B 1 ABRAKA NIGERIA	1
193.	DEPARTMENT OF MATHEMATICS FACULTY OF SCIENCE MANSOURA UNIVERSITY EGYPT	1
194.	DEPARTMENT OF MATHEMATICS FACULTY OF SCIENCE UNIVERSITI PUTRA MALAYSIA UPM SERDANG SELANGOR 43400 MALAYSIA	1
195.	DEPARTMENT OF MATHEMATICS FACULTY OF SCIENCE ZAGAZIG UNIVERSITY ZAGAZIG 44519 EGYPT	1
196.	DEPARTMENT OF MATHEMATICS FACULTY OF SCIENCES YUZUNCU YIL UNIVERSITY KAMPÜS VAN 65080 TURKEY	1
197.	DEPARTMENT OF MATHEMATICS GOVERNMENT COLLEGE UNIVERSITY FAISALABAD (LAYYAH CAMPUS) PAKISTAN	1
198.	DEPARTMENT OF MATHEMATICS GOVERNMENT COLLEGE UNIVERSITY FAISALABAD PAKISTAN	1
199.	DEPARTMENT OF MATHEMATICS GOVERNMENT POSTGRADUATE COLLEGE ABBOTTABAD PAKISTAN	1
200.	DEPARTMENT OF MATHEMATICS GOVERNMENT POSTGRADUATE COLLEGE NO 1 ABBOTTABAD PAKISTAN	1
201.	DEPARTMENT OF MATHEMATICS JAHANGIRNAGAR UNIVERSITY DHAKA SAVAR 1342 BANGLADESH	1
202.	DEPARTMENT OF MATHEMATICS MIRPUR UNIVERSITY OF SCIENCE AND TECHNOLOGY (MUST) AJK MIRPUR 10250 PAKISTAN	1
203.	DEPARTMENT OF MATHEMATICS MIRPUR UNIVERSITY OF SCIENCE AND TECHNOLOGY (MUST) MIRPUR AJK 10250 PAKISTAN	1

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204.	DEPARTMENT OF MATHEMATICS SCHOOL OF SCIENCE UNIVERSITY OF MANAGEMENT AND TECHNOLOGY C-II JOHAR TOWN LAHORE PAKISTAN	1
205.	DEPARTMENT OF MATHEMATICS SIR SYED UNIVERSITY OF ENGINEERING AND TECHNOLOGY KARACHI PAKISTAN	1
206.	DEPARTMENT OF MATHEMATICS TAIYUAN NORMAL UNIVERSITY CHINA	1
207.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF ENGINEERING & TECHNOLOGY LAHORE 54890 PAKISTAN	1
208.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF ENGINEERING & TECHNOLOGY LAHORE PAKISTAN	1
209.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF KARACHI KARACHI PAKISTAN	1
210.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF MALAKAND CHAKDARA DIR(L) PAKISTAN	1
211.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF MALAKAND CHAKDARA PAKISTAN	1
212.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF MANAGEMENT AND TECHNOLOGY LAHORE PAKISTAN	1
213.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF SARGODHA SARGODHA 40100 PAKISTAN	1
214.	DEPARTMENT OF MATHEMATICS UNIVERSITY OF SINDH LAAR CAMPUS SINDH BADIN PAKISTAN	1
215.	DEPARTMENT OF MECHANICAL ENGINEERING CHUNG ANG UNIVERSITY SEOUL 06974 SOUTH KOREA	1
216.	DEPARTMENT OF MECHANICAL ENGINEERING COLLEGE OF ENGINEERING PRINCE MOHAMMAD BIN FAHD UNIVERSITY AL-KHOBAR 31952 SAUDI ARABIA	1
217.	DEPARTMENT OF MECHANICAL ENGINEERING DARMA PERSADA UNIVERSITY JAKARTA INDONESIA	1
218.	DEPARTMENT OF MECHANICAL ENGINEERING DARMA PERSADA UNIVERSITY JL TAMAN MALAKA SELATAN NO 22 JAKARTA 13450 INDONESIA	1
219.	DEPARTMENT OF MECHANICAL ENGINEERING UNIVERSITY OF CENTRAL PUNJAB LAHORE 54000 PAKISTAN	1
220.	DEPARTMENT OF MECHANICAL ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR PAKISTAN	1
221.	DEPARTMENT OF MECHATRONICS ENGINEERING AIR UNIVERSITY ISLAMABAD PAKISTAN	1
222.	DEPARTMENT OF MEDICAL LABORATORY SCIENCE FACULTY OF APPLIED HEALTH SCIENCE THE HASHEMITE UNIVERSITY PO BOX 330127 ZARQA 13133 JORDAN	1
223.	DEPARTMENT OF PHYSICS BAHAUDDIN ZAKARIYA UNIVERSITY MULTAN 60800 PAKISTAN	1
224.	DEPARTMENT OF PHYSICS GOVERNMENT COLLEGE UNIVERSITY FAISALABAD 38000 PAKISTAN	1
225.	DEPARTMENT OF PHYSICS THE UNIVERSITY OF LAHORE LAHORE 53700 PAKISTAN	1
226.	DEPARTMENT OF PHYSICS UNIVERSITY OF AGRICULTURE FAISALABAD 38040 PAKISTAN	1

S. No.	Affiliations	Articles
227.	DEPARTMENT OF PHYSICS UNIVERSITY OF AGRICULTURE FAISALABAD PAKISTAN	1
228.	DEPARTMENT OF PHYSICS UNIVERSITY OF KARACHI KARACHI PAKISTAN	1
229.	DEPARTMENT OF PHYSICS UNIVERSITY OF PESHAWAR PESHAWAR PAKISTAN	1
230.	DEPARTMENT OF PUBLIC HEALTH ENGINEERING DISTRICT DIR UPPER PAKISTAN	1
231.	DEPARTMENT OF QUANTITATIVE METHODS SBE UNIVERSITY OF MANAGEMENT AND TECHNOLOGY LAHORE PAKISTAN	1
232.	DEPARTMENT OF SOFTWARE ENGINEERING BAHRIA UNIVERSITY KARACHI CAMPUS PAKISTAN	1
233.	DEPARTMENT OF SOFTWARE ENGINEERING UNIVERSITY OF MALAKAND CHAKDARA PAKISTAN	1
234.	DEPARTMENT OF STATISTICS BAHAUDDIN ZAKARIYA UNIVERSITY MULTAN PAKISTAN	1
235.	DEPARTMENT OF STATISTICS FEDERAL URDU UNIVERSITY OF ARTS SCIENCE AND TECHNOLOGY KARACHI PAKISTAN	1
236.	DEPARTMENT OF STATISTICS GC UNIVERSITY LAHORE PAKISTAN	1
237.	DEPARTMENT OF STATISTICS GOVERNMENT COLLEGE UNIVERSITY FAISALABAD PAKISTAN	1
238.	DEPARTMENT OF STATISTICS GOVERNMENT COLLEGE UNIVERSITY LAHORE PAKISTAN	1
239.	DEPARTMENT OF STATISTICS GOVERNMENT SADIQ ABBAS POST GRADUATE COLLEGE DERA NAWAB SAHIB PAKISTAN	1
240.	DEPARTMENT OF STATISTICS GOVERNMENT SADIQ EGERTON COLLEGE BAHAWALPUR PAKISTAN	1
241.	DEPARTMENT OF STATISTICS GOVT S A POSTGRADUATE COLLEGE DERA NAWAB SAHIB BAHAWALPUR PAKISTAN	1
242.	DEPARTMENT OF STATISTICS GOVT S A POSTGRADUATE COLLEGE DERA NAWAB SAHIB PAKISTAN	1
243.	DEPARTMENT OF STATISTICS QUAID-E-AZAM UNIVERSITY ISLAMABAD PAKISTAN	1
244.	DEPARTMENT OF STATISTICS THE ISLAMIA UNIVERSITY OF BAHAWALPUR PAKISTAN	1
245.	DEPARTMENT OF STATISTICS UNIVERSITY OF SARGODHA PAKISTAN	1
246.	DEPARTMENT OF TELECOMMUNICATION ENGINEERING BUITEMS TAKATU CAMPUS QUETTA PAKISTAN	1
247.	DEPARTMENT OF TELECOMMUNICATION ENGINEERING UET MARDAN PAKISTAN	1
248.	DEPARTMENT OF TELECOMMUNICATION ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR PAKISTAN	1
249.	DEPARTMENT OF TRANSPORTATION ENGINEERING & MANAGEMENT UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
250.	DEPARTMENT OF TRANSPORTATION ENGINEERING UNIVERSITY OF ENGINEERING & TECHNOLOGY LAHORE PAKISTAN	1
251.	DEPARTMENT OF URBAN AND REGIONAL PLANNING UNIVERSITY OF PESHAWAR PESHAWAR PAKISTAN	1

S. No.	Affiliations	Articles
252.	DEPARTMENT OF URBAN STUDIES MALMÖ UNIVERSITY NORDENSKIÖLDSGATAN 1 MALMO 21119 SWEDEN	1
253.	DEPARTMENT OF WATER MANAGEMENT ESTONIAN UNIVERSITY OF LIFE SCIENCES TARTU ESTONIA	1
254.	DIVISION OF SCIENCE AND TECHNOLOGY UNIVERSITY OF EDUCATION LAHORE PAKISTAN	1
255.	DR YARO LABORATORY AHRO INSTITUTE OF HEALTH SCIENCES AND RESEARCH 272 BATH STREET GLASGOW G2 4JR UNITED KINGDOM	1
256.	EARTH OBSERVATION CENTRE (EOC) INSTITUTE OF CLIMATE CHANGE UNIVERSITI KEBANGSAAN MALAYSIA MALAYSIA	1
257.	ELECTRICAL ENGINEERING DEPARTMENT CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY ISLAMABAD PAKISTAN	1
258.	ELECTRICAL ENGINEERING DEPARTMENT NFC INSTITUTE OF ENGINEERING AND FERTILIZER RESEARCH FAISALABAD PAKISTAN	1
259.	ELECTRICAL ENGINEERING DEPARTMENT UET PESHAWAR (MARDAN CAMPUS) PAKISTAN	1
260.	ELECTRICAL ENGINEERING DEPARTMENT UET PESHAWAR PAKISTAN	1
261.	ELECTRICAL ENGINEERING DEPARTMENT UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE 54890 PAKISTAN	1
262.	ELECTRICAL ENGINEERING DEPARTMENT UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
263.	ELECTRICAL ENGINEERING DEPARTMENT UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR BANNU CAMPUS PAKISTAN	1
264.	ELECTRICAL ENGINEERING DEPARTMENT UNIVERSITY OF ENGINEERING AND TECHNOLOGY TAXILA PAKISTAN	1
265.	ELECTRICAL ENGINEERING DEPT UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
266.	ELITE CONSTRUTION ISLAMABAD PAKISTAN	1
267.	ENGINEERING MANAGEMENT AND CONSTRUCTION COMPANY LAHORE PAKISTAN	1
268.	ENVIRONMENTAL PROTECTION AGENCY LAHORE PAKISTAN	1
269.	FACULTY OF CIVIL ENGINEERING SIR SYED UNIVERSITY OF ENGINEERING & TECHNOLOGY KARACHI 75300 PAKISTAN	1
270.	FACULTY OF CIVIL ENGINEERING UNIVERSITI TEKNOLOGI MARA MALAYSIA	1
271.	FACULTY OF COMPUTER AND INFORMATION SYSTEM ISLAMIC UNIVERSITY OF MADINAH KSA SAUDI ARABIA	1
272.	FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY UNIVERSITY OF MALAYA50603 MALAYSIA	1
273.	FACULTY OF ELECTRICAL AND ELECTRONICS ENGINEERING (FEEE) HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY AND EDUCATION (HCMUTE) 01 VO VAN NGAN STREET THU DUC DISTRICT HO CHI MINH CITY VIET NAM	1
274.	FACULTY OF ELECTRICAL ENGINEERING SAHAND UNIVERSITY OF TECHNOLOGY SAHAND NEW TOWN TABRIZ IRAN	1
275.	FACULTY OF ENGINEERING UNIVERSITY OF CENTRAL PUNJAB 1-KHAYABAN-E-JINNAH ROAD LAHORE 54000 PAKISTAN	1

S. No.	Affiliations	Articles
276.	FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY BALOCHISTAN UNIVERSITY OF IT ENGINEERING & MANAGEMENT SCIENCES PAKISTAN	1
277.	FACULTY OF INFORMATION AND TECHNOLOGY UNIVERSITY OF CENTRAL PUNJAB LAHORE PAKISTAN	1
278.	FACULTY OF NURSING WIDYA MANDALA CATHOLIC UNIVERSITY SURABAYA INDONESIA	1
279.	FACULTY OF PHARMACY UNIVERSITY OF LAHORE LAHORE PAKISTAN	1
280.	FACULTY OF PHILOSOPHY UNIVERSITAS GADJAH MADA JL OLAHRAGA CATURTUNGGAL DEPOK SLEMAN YOGYAKARTA 55281 INDONESIA	1
281.	FACULTY OF PHILOSOPHY UNIVERSITAS GADJAH MADA JL OLAHRAGA DEPOK CATURTUNGGAL SLEMAN YOGYAKARTA SPECIAL REGION 55281 INDONESIA	1
282.	FACULTY OF TECHNOLOGY MANAGEMENT AND TECHNOPRENEURSHIP UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTEM) MALAYSIA	1
283.	FACULTY OF TEXTILE TECHNOLOGY UNIVERSITY OF ZAGREB ZAGREB 10000 CROATIA	1
284.	FRIEDRICH REINHOLD KREUTZWALDI 1A TARTU 51014 ESTONIA	1
285.	GC UNIVERSITY FAISALABAD DEPARTMENT OF STATISTICS PAKISTAN	1
286.	GEOPHYSICS LABORATORY UNIVERSITAS GADJAH MADA SEKIP UTARA BLS 21 YOGYAKARTA 55281 INDONESIA	1
287.	GOVERNMENT COLLEGE OF TECHNOLOGY ABBOTTABAD PAKISTAN	1
288.	GOVERNMENT DYAL SING COLLEGE LAHORE PAKISTAN	1
289.	GOVERNMENT POST GRADUATE COLLEGE SWABIKP PAKISTAN	1
290.	GOVT DEGREE COLLEGE FOR BOYS MAKHDOOM RASHID MULTAN PAKISTAN	1
291.	GRADUATE SCHOOL OF RENEWABLE ENERGY DARMA PERSADA UNIVERSITY JAKARTA INDONESIA	1
292.	GRADUATE SCHOOL OF RENEWABLE ENERGY DARMA PERSADA UNIVERSITY JL TAMAN MALAKA SELATAN NO 22 JAKARTA 13450 INDONESIA	1
293.	HIGHER EDUCATION DEPARTMENT GOVERNMENT OF PUNJAB PAKISTAN	1
294.	INSTITUTE FOR COMPUTING AND INFORMATION SCIENCE RADBOUND UNIVERSITY COMENISULAAN 4 NIJMEGEN 6525 HP NETHERLANDS	1
295.	INSTITUTE MATHEMATICS AND COMPUTER SCIENCE UNIVERSITY OF SINDH JAMSHORO PAKISTAN	1
296.	INSTITUTE OF BUSINESS AND MANAGEMENT UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
297.	INSTITUTE OF BUSINESS MANAGEMENT & ADMINISTRATIVE STUDIES THE ISLAMIA UNIVERSITY OF BAHAWALPUR PAKISTAN	1
298.	INSTITUTE OF CHEMISTRY UNIVERSITY OF THE PUNJAB LAHORE PAKISTAN	1
299.	INSTITUTE OF CIVIL ENGINEERING TECHNICAL UNIVERSITY BERLIN GERMANY	1
300.	INSTITUTE OF GEOLOGY UNIVERSITY OF AZAD JAMMU & KASHMIR MUZAFFARABAD PAKISTAN	1
301.	INSTITUTE OF MECHATRONICS ENGINEERING UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR PAKISTAN	1

S. No.	Affiliations	Articles
302.	INSTITUTE OF SPACE AND PLANETARY ASTROPHYSICS UNIVERSITY OF KARACHI KARACHI 75270 PAKISTAN	1
303.	INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY UNIVERSITY OF KARACHI KARACHI PAKISTAN	1
304.	INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY UNIVERSITY OF KARACHI PAKISTAN	1
305.	INSTITUTE OF STRATEGIC INDUSTRIAL DECISION MODELING SCHOOL OF QUANTITATIVE SCIENCES COLLEGE OF ARTS AND SCIENCES UNIVERSITI UTARA MALAYSIA SINTOK KEDAH 06010 MALAYSIA	1
306.	INTERNAL MEDICINE WARD RSUP DR SARDJITO FACULTY OF MEDICINE UNIVERSITAS GADJAH MADA JALAN KESEHATAN KABUPATEN SLEMAN YOGYAKARTA 55281 INDONESIA	1
307.	IQRA UNIVERSITY ISLAMABAD PAKISTAN	1
308.	KARAKORAM INTERNATIONAL UNIVERSITY GILGIT PAKISTAN	1
309.	KYRGYZ NATIONAL UNIVERSITY NAMED AFTER JUSUP BALASAGYN KYRGYZSTAN	1
310.	LMNO UNIVERSITY OF CAEN-NORMANDIE CAEN 14032 FRANCE	1
311.	MATERIALS SCIENCE PROGRAM FACULTY OF ENGINEERING NIIGATA UNIVERSITY NIIGATA CITY NIIGATA 950-2181 JAPAN	1
312.	MECHANICAL ENGINEERING DEPARTMENT COMSATS INSTITUTE OF INFORMATION TECHNOLOGY SAHIWAL PAKISTAN	1
313.	MECHANICAL ENGINEERING DEPARTMENT UNIVERSITY OF ENGINEERING & TECHNOLOGY LAHORE KSK CAMPUS PAKISTAN	1
314.	MECHANICAL ENGINEERING DEPARTMENT UNIVERSITY OF ENGINEERING & TECHNOLOGY LAHORE PAKISTAN	1
315.	MECHANICAL ENGINEERING DEPARTMENT UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
316.	MILITARY COLLEGE OF ENGINEERING NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY RISALPUR 44000 PAKISTAN	1
317.	MINDANAO STATE UNIVERSITY ILLIGAN INSTITUTE OF TECHNOLOGY ANDRES BONIFACIO AVE ILLIGAN CITY ILIGAN CITY LANAO DEL NORTE 9200 PHILIPPINES	1
318.	MINISTRY OF PUBLIC WORKS AND HOUSING JALAN PATTIMURA NO 20 JAKARTA 12110 INDONESIA	1
319.	NANO-SCALE PHYSICS LABORATORY DEPARTMENT OF PHYSICS AIR UNIVERSITY ISLAMABAD PAKISTAN	1
320.	NANOTECHNOLOGY RESEARCH CENTER DEPARTMENT OF PHYSICS UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
321.	NATIONAL ADVANCED AUTOMATION AND ELECTRONICS RESEARCH UNIT 112 PHAHONYOTHIN ROAD KHLONG NUENG KHLONG LUANG DISTRICT PATHUMTHANI 12120 THAILAND	1
322.	NATIONAL CENTER OF EXCELLENCE IN PHYSICAL CHEMISTRY (NCE) UNIVERSITY OF PESHAWAR25120 PAKISTAN	1
323.	NATIONAL COLLEGE OF BUSINESS ADMINISTRATION & ECONOMICS LAHORE PAKISTAN	1
324.	NATIONAL INSTITUTE OF TECHNOLOGY DIMAPUR CHUMUKEIDMA NAGALAND 797103 INDIA	1

S. No.	Affiliations	Articles
325.	NATIONAL INSTITUTE OF TRANSPORTATION NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY ISLAMABAD 44000 PAKISTAN	1
326.	NUCLEAR INSTITUTE OF AGRICULTURE AND BIOLOGY (NIAB) FAISALABAD PAKISTAN	1
327.	OFFICE OF CONTROLLER OF EXAMINATION MINHAJ UNIVERSITY LAHORE PAKISTAN	1
328.	PAKISTAN COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH LABORATORIES COMPLEX LAHORE PAKISTAN	1
329.	PAKISTAN TELECOMMUNICATION COMPANY LIMITED ISLAMABAD PAKISTAN	1
330.	PHYSICS DEPARTMENT FACULTY OF MATHEMATICS AND NATURAL SCIENCE UNIVERSITAS GADJAH MADA SEKIP UTARA BULAKSUMUR YOGYAKARTA 55281 INDONESIA	1
331.	POLITECNICO DI TORINO TURIN ITALY	1
332.	PRASARANA UKM UNIVERSITI KEBANGSAAN MALAYSIA MALAYSIA	1
333.	PRIMARY & SECONDARY HEALTHCARE DEPARTMENT LAHORE PAKISTAN	1
334.	PRIMARY AND SECONDARY HEALTHCARE DEPARTMENT LAHORE PAKISTAN	1
335.	PROGRAM STUDY OF INFORMATION TECHNOLOGY UNIVERSITY OF JEMBER JL KALIMANTAN 37 JEMBER 68121 INDONESIA	1
336.	PROGRAMME ARCHITECTURE SCHOOL OF HOUSING BUILDING & PLANNING UNIVERSITI SAINS MALAYSIA PENANG 11800 MALAYSIA	1
337.	PT WIJAYA KARYA BETON JALAN BIRU LAUT X NO 20-21 JAKARTA 13340 INDONESIA	1
338.	RENEWABLE ENERGY RESEARCH CENTER & POWER AND ENERGY SYSTEM SIMULATION LABORATORY NATIONAL INSTITUTE OF TECHNOLOGY MALANG JL RAYA KARANGLO KM 2 MALANG 65153 INDONESIA	1
339.	RENEWABLE ENERGY RESEARCH CENTER NATIONAL INSTITUTE OF TECHNOLOGY MALANG JL RAYA KARANGLO KM 2 MALANG 65143 INDONESIA	1
340.	RESEARCH CENTRE FOR ACCELERATOR SCIENCE AND TECHNOLOGY (CAST) NATIONAL NUCLEAR ENERGY AGENCY (BATAN) JALAN BABARSARI YOGYAKARTA 55281 INDONESIA	1
341.	RESEARCH DIVISION FOR NATURAL PRODUCT TECHNOLOGY – INDONESIAN INSTITUTE OF SCIENCES JL JOGJA-WONOSARI KM 31 5 GUNUNG KIDUL YOGYAKARTA-SPECIAL REGION 55861 INDONESIA	1
342.	RESEARCH DIVISION FOR NATURAL PRODUCT TECHNOLOGY INDONESIAN INSTITUTE OF SCIENCES JL JOGJA-WONOSARI KM 31 5 GUNUNG KIDUL SPECIAL REGION YOGYAKARTA55861 INDONESIA	1
343.	RESEARCH DIVISION FOR NATURAL PRODUCT TECHNOLOGY INDONESIAN INSTITUTE OF SCIENCES JL JOGJA - WONOSARI KM 31 5 SPECIAL REGION YOGYAKARTA GUNUNG KIDUL 55861 INDONESIA	1
344.	RITSUMEIKAN ASIA-PACIFIC UNIVERSITY 1-1 JUMONJIBARU BEPPU-SHI 874-8577 JAPAN	1
345.	RITSUMEIKAN ASIA-PACIFIC UNIVERSITY 1-1 JUMONJIBARU BEPPU 874-8577 JAPAN	1

S. No.	Affiliations	Articles
346.	RITSUMEIKAN ASIA-PACIFIC UNIVERSITY 1–1 JUMONJIBARU BEPPU 874-8577 JAPAN	1
347.	SAFETTY SYSTEMS LTD UNITED KINGDOM	1
348.	SCHOOL EDUCATION DEPARTMENT (SED) GOVERNMENT OF THE PUNJAB PAKISTAN	1
349.	SCHOOL OF COMPUTER AND MATHEMATICAL SCIENCES AUCKLAND UNIVERSITY OF TECHNOLOGY AUCKLAND 1142 NEW ZEALAND	1
350.	SCHOOL OF COMPUTER AND MATHEMATICAL SCIENCES AUCKLAND UNIVERSITY OF TECHNOLOGY1142 NEW ZEALAND	1
351.	SCHOOL OF ECONOMICS AND MANAGEMENT UNIVERSITY OF CHINESE ACADEMY OF SCIENCE BEIJING CHINA	1
352.	SCHOOL OF ENGINEERING DEPARTMENT OF ELECTRICAL ENGINEERING UNIVERSITY OF MANAGEMENT & TECHNOLOGY LAHORE PAKISTAN	1
353.	SCHOOL OF NATURAL SCIENCES NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY ISLAMABAD PAKISTAN	1
354.	SCHOOL OF QUANTITATIVE SCIENCES COLLEGE OF ARTS AND SCIENCES UNIVERSITI UTARA MALAYSIA SINTOK KEDAH 06010 MALAYSIA	1
355.	SCHOOL OF RESOURCE AND CIVIL ENGINEERING NORTHEASTERN UNIVERSITY SHENYANG 110819 CHINA	1
356.	SHAYKH ZAYED ISLAMIC CENTER UNIVERSITY OF PESHAWAR PESHAWAR PAKISTAN	1
357.	SMART & SUSTAINABLE TOWNSHIP RESEARCH CENTRE FACULTY OF ENGINEERING & BUILT ENVIRONMENT UNIVERSITI KEBANGSAAN MALAYSIA MALAYSIA	1
358.	SOFTWARE ENGINEERING RESEARCH GROUP (SERG_UOM) DEPARTMENT OF COMPUTER SCIENCE & IT UNIVERSITY OF MALAKAND LOWER DIR PAKISTAN	1
359.	SOFTWARE ENGINEERING RESEARCH GROUP (SERG_UOM) DEPARTMENT OF COMPUTER SCIENCE & IT UNIVERSITY OF MALAKANDKPK PAKISTAN	1
360.	SOFTWARE ENGINEERING RESEARCH GROUP DEPARTMENT OF COMPUTER SCIENCE & IT UNIVERSITY OF MALAKAND LOWER DIR PAKISTAN	1
361.	STRATHCLYDE INSTITUTE OF PHARMACY & BIOMEDICAL SCIENCES (SIPBS) UNIVERSITY OF STRATHCLYDE SPBBS 161 CATHEDRAL ST GLASGOW G4 0RE UNITED KINGDOM	1
362.	STRUCTURAL ENGINEERING DIVISION NATIONAL ENGINEERING SERVICES LAHORE PAKISTAN	1
363.	SUPPLY CHAIN AND OPERATIONS MANAGEMENT RESEARCH GROUP MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY JAMSHORO PAKISTAN	1
364.	THE UNIVERSITY OF AGRICULTURE PESHAWAR PAKISTAN	1
365.	TRANSPORT DEPARTMENT GOVERNMENT OF THE PUNJAB LAHORE PAKISTAN	1
366.	TSINGHUA UNIVERSITY BEIJING CHINA	1
367.	UNITED ENERGY PAKISTAN KARACHI PAKISTAN	1
368.	UNIVERSITAS DJUANDA JALAN TOL CIAWI NO 1 CIAWI BOGOR 16720 INDONESIA	1

S. No.	Affiliations	Articles
369.	UNIVERSITAS GADJAH MADA SEKIP UTARA BLS 21 YOGYAKARTA 55281 INDONESIA	1
370.	UNIVERSITY INSTITUTE OF INFORMATION TECHNOLOGY PMAS-ARID AGRICULTURE UNIVERSITY RAWALPINDI PAKISTAN	1
371.	UNIVERSITY INSTITUTE OF INFORMATION TECHNOLOGY PMAS ARID AGRICULTURE UNIVERSITY RAWALPINDI PAKISTAN	1
372.	UNIVERSITY OF ENGINEERING & TECHNOLOGY MARDAN PAKISTAN	1
373.	UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE PAKISTAN	1
374.	UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR PAKISTAN	1
375.	UNIVERSITY OF KARACHI KARACHI PAKISTAN	1
376.	WASEDA UNIVERSITY GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT 3-4-1 OKUBO SHINJUKU-KU TOKYO 169-8555 JAPAN	1
377.	WATER RESOURCES DIVISION NATIONAL ENGINEERING SERVICES PAKISTAN PVT LTD LAHORE PAKISTAN	1

Table 3. List of all universities with total number of publications (NoP).

S. No.	Affiliations	Articles
1.	UNIVERSITY OF ENGINEERING AND TECHNOLOGY	54
2.	UNIVERSITY OF MALAKAND	18
3.	UNIVERSITY OF KARACHI	13
4.	UNIVERSITY OF PESHAWAR	11
5.	DARMA PERSADA UNIVERSITY	9
6.	GOVERNMENT COLLEGE UNIVERSITY	9
7.	UNIVERSITY OF THE PUNJAB	9
8.	UNIVERSITAS GADJAH MADA	8
9.	UNIVERSITY OF CENTRAL PUNJAB	8
10.	THE ISLAMIA UNIVERSITY OF BAHAWALPUR	7
11.	UNIVERSITY OF MANAGEMENT AND TECHNOLOGY	7
12.	AIR UNIVERSITY	5
13.	BAHAUDDIN ZAKARIYA UNIVERSITY	5
14.	FEDERAL URDU UNIVERSITY OF ARTS	5
15.	AIN SHAMS UNIVERSITY	4
16.	IQRA UNIVERSITY	4
17.	NATIONAL INSTITUTE OF TECHNOLOGY MALANG	4
18.	PETRA CHRISTIAN UNIVERSITY	4
19.	SHAHEED BENAZIR BHUTTO UNIVERSITY	4
20.	UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE	4
21.	HACETTEPE UNIVERSITY	3
22.	INSTITUT TEKNOLOGI SEPULUH NOPEMBER	3
23.	INSTITUTE OF SPACE TECHNOLOGY	3
24.	MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY	3
25.	NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY	3
26.	RITSUMEIKAN ASIA-PACIFIC UNIVERSITY	3

S. No.	Affiliations	Articles
27.	THE UNIVERSITY OF LAHORE	3
28.	UNIVERSITI KEBANGSAAN MALAYSIA	3
29.	UNIVERSITY OF LAHORE	3
30.	UNIVERSITY OF MUHAMMADIYAH MALANG	3
31.	COMSATS INSTITUTE OF INFORMATION TECHNOLOGY	2
32.	DEPARTMENT OF ELECTRICAL ENGINEERING	2
33.	ELECTRICAL ENGINEERING DEPARTMENT	2
34.	GOVERNMENT POSTGRADUATE COLLEGE	2
35.	GOVERNMENT SADIQ EGERTON COLLEGE	2
36.	GOVT. POSTGRADUATE COLLEGE GOJRA	2
37.	INDONESIAN INSTITUTE OF SCIENCES	2
38.	KING ABDULAZIZ UNIVERSITY	2
39.	MIRPUR UNIVERSITY OF SCIENCE AND TECHNOLOGY (MUST)	2
40.	NATIONAL INSTITUTE OF TECHNOLOGY (ITN) MALANG	2
41.	NFC INSTITUTE OF ENGINEERING AND FERTILIZER RESEARCH	2
42.	QUAID-E-AWAM UNIVERSITY OF ENGINEERING	2
43.	S. E. COLLEGE	2
44.	S.E. COLLEGE	2
45.	SIR SYED UNIVERSITY OF ENGINEERING AND TECHNOLOGY	2
46.	SUNGKYUNKWAN UNIVERSITY	2
47.	THE HASHEMITE UNIVERSITY	2
48.	UNIVERSITAS INDONESIA	2
49.	UNIVERSITI UTARA MALAYSIA	2
50.	UNIVERSITY INSTITUTE OF INFORMATION TECHNOLOGY	2
51.	UNIVERSITY OF AGRICULTURE	2
52.	UNIVERSITY OF PUNJAB	2
53.	UNIVERSITY OF SARGODHA	2
54.	UNIVERSITY OF SCIENCE AND TECHNOLOGY BANNU	2
55.	UNIVERSITY OF TARTU	2
56.	WIDYA MANDALA CATHOLIC UNIVERSITY	2
57.	ABASYN UNIVERSITY	1
58.	AHRO INSTITUTE OF HEALTH SCIENCES AND RESEARCH	1
59.	AL-MUSTANSIRIYAH UNIVERSITY	1
60.	ARAB ACADEMY FOR SCIENCE	1
61.	ARAB ACADEMY OF SCIENCE	1
62.	AUCKLAND UNIVERSITY OF TECHNOLOGY	1
63.	BAHRIA UNIVERSITY KARACHI	1
64.	BALOCHISTAN UNIVERSITY OF INFORMATION TECHNOLOGY	1
65.	BALOCHISTAN UNIVERSITY OF IT	1
66.	BANNU UNIVERSITY OF SCIENCE AND TECHNOLOGY	1
67.	BEIJING INSTITUTE OF TECHNOLOGY	1
68.	CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY	1
69.	CHENAB COLLEGE OF ENGINEERING AND TECHNOLOGY	1
70.	CHUNG ANG UNIVERSITY	1

S. No.	Affiliations	Articles
71.	COLLEGE OF ENGINEERING AND TECHNOLOGY	1
72.	COLLEGE OF TOURISM AND HOTEL MANAGEMENT (COTHM)	1
73.	COMSATS INSTITUTE OF INFORMATION AND TECHNOLOGY	1
74.	COMSATS UNIVERSITY ABBOTTABAD CAMPUS	1
75.	COMSATS UNIVERSITY ISLAMABAD	1
76.	CONCORDIA COLLEGE BAHAWALPUR	1
77.	DALIAN UNIVERSITY OF TECHNOLOGY	1
78.	DAMIETTA UNIVERSITY	1
79.	DAWOOD UNIVERSITY OF ENGINEERING AND TECHNOLOGY KARACHI	1
80.	DELTA STATE UNIVERSITY	1
81.	DEPARTMENT OF COMPUTER SCIENCE	1
82.	DEPARTMENT OF PUBLIC HEALTH ENGINEERING	1
83.	ENVIRONMENTAL PROTECTION AGENCY	1
84.	ESTONIAN UNIVERSITY OF LIFE SCIENCES	1
85.	FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY	1
86.	FEDERAL URDU UNIVERSITY OF ARTS SCIENCE AND TECHNOLOGY	1
87.	FORMAN CHRISTIAN COLLEGE UNIVERSITY	1
88.	GC UNIVERSITY FAISALABAD	1
89.	GC UNIVERSITY LAHORE	1
90.	GLIM INSTITUTE OF MODERN STUDIES	1
91.	GOVERNMENT COLLEGE OF TECHNOLOGY	1
92.	GOVERNMENT COLLEGE UNIVERSITY FAISALABAD (LAYYAH CAMPUS)	1
93.	GOVERNMENT DYAL SING COLLEGE LAHORE	1
94.	GOVERNMENT POST GRADUATE COLLEGE	1
95.	GOVERNMENT SADIQ ABBAS POST GRADUATE COLLEGE	1
96.	GOVT DEGREE COLLEGE FOR WOMEN AHMADPUR EAST	1
97.	GOVT. DEGREE COLLEGE FOR BOYS MAKHDOOM RASHID	1
98.	GOVT. SADIQ EGERTON GRADUATE COLLEGE	1
99.	HANKUK UNIVERSITY OF FOREIGN STUDIES	1
100.	HIGHER INSTITUTE FOR ENGINEERING AND TECHNOLOGY	1
101.	HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY AND EDUCATION (HCMUTE)	1
102.	INSTITUTE FOR COMPUTING AND INFORMATION SCIENCE	1
103.	INSTITUTE OF BUSINESS MANAGEMENT	1
104.	INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA	1
105.	ISLAMIA COLLEGE UNIVERSITY PESHAWAR	1
106.	ISLAMIC UNIVERSITY OF MADINAH KSA	1
107.	JAHANGIRNAGAR UNIVERSITY	1
108.	KARAKORAM INTERNATIONAL UNIVERSITY	1
109.	KING ABDUL-AZIZ UNIVERSITY	1
110.	KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY	1
111.	KUMOH NATIONAL INSTITUTE OF TECHNOLOGY	1
112.	KYRGYZ NATIONAL UNIVERSITY NAMED AFTER JUSUP BALASAGYN	1
113.	LAHORE COLLEGE FOR WOMEN UNIVERSITY	1
114.	LAHORE UNIVERSITY OF MANAGEMENT SCIENCES	1

S. No.	Affiliations	Articles
115.	MALMÖ UNIVERSITY	1
116.	MANSOURA UNIVERSITY	1
117.	MINDANAO STATE UNIVERSITY	1
118.	MINHAJ UNIVERSITY	1
119.	MIRPUR UNIVERSITY OF SCIENCE AND TECHNOLOGY [MUST]	1
120.	MNS UNIVERSITY OF ENGINEERING AND TECHNOLOGY	1
121.	NAROTAMA UNIVERSITY	1
122.	NATIONAL ADVANCED AUTOMATION AND ELECTRONICS RESEARCH UNIT	1
123.	NATIONAL CENTER OF EXCELLENCE IN PHYSICAL CHEMISTRY (NCE)	1
124.	NATIONAL COLLEGE OF BUSINESS ADMINISTRATION AND ECONOMICS	1
125.	NATIONAL INSTITUTE OF TECHNOLOGY	1
126.	NATIONAL TEXTILE UNIVERSITY	1
127.	NIIGATA UNIVERSITY	1
128.	NORTHEASTERN UNIVERSITY	1
129.	NUCLEAR INSTITUTE OF AGRICULTURE AND BIOLOGY (NIAB)	1
130.	NUST COLLEGE OF ELECTRICAL AND MECHANICAL ENGINEERING	1
131.	PAKISTAN COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH LABORATORIES COMPLEX	1
132.	PANCASILA UNIVERSITY	1
133.	POLITECNICO DI TORINO	1
134.	PRIMARY AND SECONDARY HEALTHCARE DEPARTMENT	1
135.	PRIMARY AND SECONDARY HEALTHCARE DEPARTMENT LAHORE	1
136.	PRINCE MOHAMMAD BIN FAHD UNIVERSITY	1
137.	PRINCE SATTAM BIN ABDULAZIZ UNIVERSITY	1
138.	QUAID-E-AZAM UNIVERSITY	1
139.	RESEARCH CENTRE FOR ACCELERATOR SCIENCE AND TECHNOLOGY (CAST)	1
140.	RESEARCH DIVISION FOR NATURAL PRODUCT TECHNOLOGY – INDONESIAN INSTITUTE OF SCIENCES	1
141.	S.A. POSTGRADUATE COLLEGE	1
142.	S.A. POSTGRADUATE. COLLEGE	1
143.	SAHAND UNIVERSITY OF TECHNOLOGY	1
144.	SCHOOL EDUCATION DEPARTMENT (SED)	1
145.	SCHOOL OF COMPUTER AND MATHEMATICAL SCIENCES	1
146.	SEPULUH NOPEMBER INSTITUTE OF TECHNOLOGY (ITS)	1
147.	SHAH ABDUL LATIF UNIVERSITY	1
148.	SHAHEED ZULFIKAR ALI BHUTTO INSTITUTE OF SCIENCE AND TECHNOLOGY (SZABIST)	1
149.	SHAHEED ZULFIQAR ALI BHUTTO INSTITUTE OF SCIENCE AND TECHNOLOGY	1
150.	SHIPBUILDING INSTITUTE OF POLYTECHNIC SURABAYA	1
151.	SINDH MADRASATUL ISLAM UNIVERSITY	1
152.	TAIYUAN NORMAL UNIVERSITY	1
153.	TECHNICAL UNIVERSITY BERLIN	1
154.	THE BRITISH UNIVERSITY IN EGYPT	1
155.	THE UNIVERSITY OF AGRICULTURE	1

S. No.	Affiliations	Articles
156.	THE UNIVERSITY OF FAISALABAD	1
157.	TSINGHUA UNIVERSITY	1
158.	UNIVERSITAS CIPUTRA	1
159.	UNIVERSITAS DJUANDA	1
160.	UNIVERSITAS SYIAH KUALA	1
161.	UNIVERSITAT POLITE`CNICA DE CATALUNYA	1
162.	UNIVERSITI PUTRA MALAYSIA	1
163.	UNIVERSITI SAINS MALAYSIA	1
164.	UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTEM)	1
165.	UNIVERSITI TEKNOLOGI MARA	1
166.	UNIVERSITY OF AZAD JAMMU AND KASHMIR	1
167.	UNIVERSITY OF BALOCHISTAN	1
168.	UNIVERSITY OF BALUCHISTAN	1
169.	UNIVERSITY OF CAEN-NORMANDIE	1
170.	UNIVERSITY OF CHINESE ACADEMY OF SCIENCE	1
171.	UNIVERSITY OF EDUCATION	1
172.	UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE KSK	1
173.	UNIVERSITY OF ENGINEERING AND TECHNOLOGY PESHAWAR	1
174.	UNIVERSITY OF JEMBER	1
175.	UNIVERSITY OF KHARTOUM	1
176.	UNIVERSITY OF LATVIA	1
177.	UNIVERSITY OF MALAKANDKPK	1
178.	UNIVERSITY OF MANAGEMENT AND TECHNOLOGY (UMT)	1
179.	UNIVERSITY OF MANAGEMENT AND TECHNOLOGY C-II	1
180.	UNIVERSITY OF MANAGEMENT AND TECHNOLOGY LAHORE	1
181.	UNIVERSITY OF MICHIGAN	1
182.	UNIVERSITY OF SCIENCE AND TECHNOLOGY	1
183.	UNIVERSITY OF SINDH JAMSHORO	1
184.	UNIVERSITY OF SINDH LAAR CAMPUS	1
185.	UNIVERSITY OF STRATHCLYDE	1
186.	UNIVERSITY OF SWABI	1
187.	UNIVERSITY OF SWAT	1
188.	UNIVERSITY OF ZAGREB	1
189.	WASEDA UNIVERSITY	1
190.	WATER RESOURCES DIVISION	1
191.	YUZUNCU YIL UNIVERSITY	1
192.	ZAGAZIG UNIVERSITY	1

Table 4. List of all countries with total articles.

S. No.	Country	Articles
1.	Pakistan	150
2.	Indonesia	20
3.	Malaysia	7
4.	Saudi Arabia	7
5.	Japan	6
6.	China	5
7.	South Korea	5
8.	Egypt	4
9.	Turkey	4
10.	Estonia	3
11.	Jordan	2
12.	New Zealand	2
13.	Philippines	2
14.	United Kingdom	2
15.	Bangladesh	1
16.	Croatia	1
17.	France	1
18.	Germany	1
19.	India	1
20.	Iran	1
21.	Iraq	1
22.	Italy	1
23.	Kyrgyzstan	1
24.	Latvia	1
25.	Netherlands	1
26.	Nigeria	1
27.	Spain	1
28.	Sudan	1
29.	Sweden	1
30.	Thailand	1
31.	United States	1
32.	Viet Nam	1

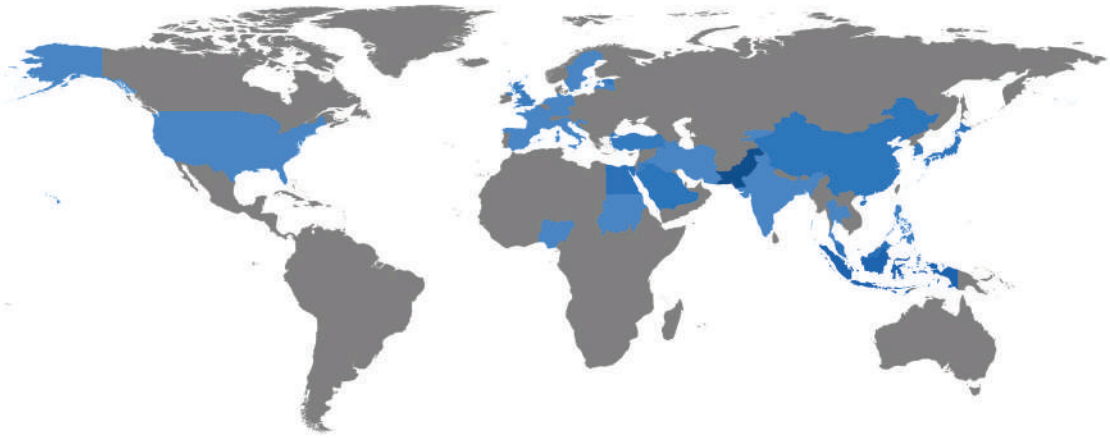

Fig. 1. Country co-authorship network

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Research Article

Economical Synthesis of Nitrophenols under Controlled Physical Parameters

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Abstract: Current studies were performed to find an economical path for the synthesis of nitrophenols which are plant growth regulators (PGR) and are applied to crops for better agricultural production. The study discourages the involvement of costly surfactants such as CTAB, TBAB, H-β and γ-alumina catalysts in commercial production of nitrophenols. This synthesis requires the lower number of chemicals, less time and does not involve the advance instruments. Phenol and its derivatives were selectively nitrated into o/p nitrophenols economically by controlling only the physical parameters, i.e., dilution of nitric acid, reaction time and reaction temperature. The synthesised products were characterised by RP-HPLC and gas chromatography. The reaction between 98% phenol and 32.5% nitric acid at a temperature of 20°C (±2°C) required only 1 hour for optimum yield (91%) of nitrophenols with 77% ortho and 14% para selectivity and was found to have the most suitable route for economical production. The investigated synthetic path is relatively clean and environmentally friendly as it does not involve catalysts and solvents, like the conventional processes. This process may be adopted for commercialisation and industrial level production of nitrophenols for agricultural purposes.

Keywords: Phenol, Nitration, Nitrophenols, o/p-selectivity, Yield, Economical

1. INTRODUCTION

Nitrophenols are synthetic chemicals or plant hormones which are effective at very low concentrations to regulate plant growth. They are organic compounds (instead of nutrients) that stimulate the physiological processes of the plant and improve their metabolic processes [1]. In industries, the nitration of aromatics are widely studied and utilised [2] for agricultural and medicinal purposes. Since it is necessary to use mixed acids such as concentrated nitric acid and sulfuric acid, the nitrification processes in general are not environmentally friendly and lead to significant discharge of acid wastes [3, 4]. Many nitration processes involve the use of conc. nitric acid, acid anhydrides, sulfonic acids, metal nitrates [5] and nitrogen oxides [6]. Nitration of phenolic compounds with conc. nitric acid also leads to the formation of many by-products including 2,4-dinitro and 2,4,6-trinito (picric acid) at high temperature [7]. The ordinary yields of the nitrophenols by direct nitration do not exceed than 60% due to side reactions [8]. Therefore, by using suitable catalysts,

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proper reaction conditions and controlled physical parameters, the side reactions can be overcome [9]. Phenols can be nitrated by using the mixtures of dilute nitric acid and sulfuric acid in a suitable ratio (e.g., 1:42) [10]. However, these mixtures are less selective for the formation of the desired isomers i.e., o-nitrophenol and p-nitrophenol [11]. The use of fuming acids is not recommended for nitration because such acids may generate large amounts of fumes in the environment during the course of a reaction [12]. Attempts are being made to reduce the quantities of spent acids and to increase selectivity by replacing the catalysts with the appropriate solvents. The nitration of phenol over solid acid catalysts is an easy procedure for quantitative separation of products as compared to the conventional processes. Nitration of industrial aromatics commonly involves drug synthesis [13]. By using a mixture of nitric acid and sulfuric acid, most of phenolic reactions give mainly ortho isomers with some quantities of para compounds. Zeolite-based solid acid catalysts have also been employed in industries for economical production of nitrophenols; these catalysts include silica-supported sulfuric acid and p-toluene sulfonic acid [4], heteropolyacids [14], silica chloride [15] and nanosized tungsten oxide supported on sulfated SnO2 [16]. Regioselectivity of *o/p* nitrophenols was also successively investigated by using simple phenols with 2,4,6 trichloro thiazine [1,3,5]; this process is considered novel for green chemistry [17, 18]. The mechanism of nitration has been extensively investigated and different reviews have been published [19]. Concentrated nitric acid and sulfuric acid have been used for nitration of benzene, alkylbenzene and fragrance compounds [20]. Numerous nitration methodologies were developed for mild nitration-active aromatic compounds such as phenol and pyrroles [21]. Ferric nitrate, copper nitrate and vanadium nitrate were also used to increase the required conversion and selectivity [22]. The regioselectivity of phenol can be improved with silica-supported solid acid catalysts and is considered a noble approach for minimising the side reactions [23]. An excellent pathway for regioselective synthesis of nitrophenols from phenol and its derivative was observed by chelation of o-nitrophenol with carbon-carbon atoms [24]. The metals like Ru [25, 26], Rh [27] and Pd [28] were also employed for selective *o/p* nitration of phenol derivatives. However, less attention have been given towards the use of first row transition metals for nitration purposes [29]. Nitrophenols also exist in various forms in gas phase clouds and rainwater in the atmosphere [30]. The rate of nitration reaction in aqueous phase is more favorable as compared to that in the gaseous phase [31]. It has been experimentally confirmed that some atmospheric species split into nitrate radicals in aqueous phase of atmosphere in the presence of UV irradiations [32] and nitrogen dioxide ($NO2^{+}$) [33], nitrous acid (HONO) [34], nitrate (NO_3^{-}) and nitrite (NO_2^{-}) [35]. The other two nitrating reagents N_2O_5 and Cl-NO_2 are proposed for atmospheric region potential [36]. Hurdles of regioselective nitration can be resolved by ipso-nitration which involves the organo-metallic reagents for demetalation [37, 38]. Currently *ipso*-nitration has been reported by using tert-butyl nitrite as the nitrating agent [39]. Historically, the procedures for phenolic nitration have many troubles including low selectivity, difficulty to handle *etc*. [40].

Current studies were performed to introduce an economical path for nitrophenol synthesis by controlling only the physical parameters, i.e., nitric acid concentration, reaction time and temperature. This investigation may reduce the cost of nitrophenols which are plant growth regulators (PGR) and are applied to crops for better agricultural yield. The study discourages the use of costly surfactants such as (CTAB, TBAB, H-β and γ-alumina catalysts) which are commonly used for commercial production of nitrophenols. This synthesis requires fewer chemicals and less time and does not involve the advance instruments.

2. MATERIALS AND METHODS

IHigh purity analytical grade reagents as phenol, substituted phenols and nitrating agents were purchased from Sigma Aldrich, Germany and employed in experiments without any additional purification. High purity analytical standards namely o-nitrophenol and p-nitrophenol (Chem service USA) having purities of 99.5% and 99.8%, respectively were used for quantification purposes. The concentrated nitric acid and its various dilutions (65%, 50%, 40% & 32.5%) were used. The dilution of nitric acid was performed with a specified volume of distilled water. The reaction temperature during various time intervals was also specified. Special

focus was made to control the internal temperature of the reaction by the circulation of cooled water and dilution of a nitrating agent around the reactor bath during the course of the reaction.

2.1 Sample preparation for GC

A specific quantity of sample was taken and diluted in 10 mL of 0.1% BHT solution and introduced into the GC system.

2.2 General synthetic procedure

Nitrating agent in concentrated and various diluted forms (65%, 50%, 40% & 32.5%) was added into the phenol substrate. The nitrating agent's flow and the reaction mixture's temperature were maintained with an adjustable flow meter and cooled water circulation. The color of the reaction matrix was initially yellowish; it was then changed to reddish brown, indicating the consumption of phenol. The product was extracted with dichloromethane and ethanol; the contents were dried in a heating oven for quantification purposes with RP-HPLC and gas chromatography.

2.3 Economical Synthesis

A series of experiments were performed with different concentrations of nitrants at different temperatures. The experiment was conducted with 32.5% (w/v) dilute nitric acid in a batch reactor. For this experiment, 5.0 g of phenol was taken into a reaction vessel and a controlled burette added 8.21 g of nitric acid solution. The reaction vessel was equipped with a stirrer (speed 200-1500 rpm, temperature controller +5°C-380°C, platform 15.5 x 15.5 cm and electrical power 230 V / 60 Hz). A burette probe monitored the flow of dilute acid. The mixture was stirred thoroughly during the reaction. At the first drop of acid addition, the brown-red vapors were formed which raised the temperature of the mixture upon further addition. The slow addition of acid was continued until thick viscous nitrophenol was precipitated in the reaction vessel. The product was collected in another beaker after separation by a separatory funnel for analytical purposes. The post-treatment of the reaction was carried out with dichloromethane and the solvent was evaporated in an oven at 60°C. A tuned thermocouple was used to monitor the temperature rise. It is therefore important to carry out the reaction at low temperature for safety, and it is also important that the reactor must be connected to the cooling system from the outside in order to control the reaction temperature during all the experiments. The extracted product was examined with RP-HPLC with Lc-20AT pump, LC solution software, and C-18 analytical column having dimensions (250mm x 4.6mm) with particle size 5.0µm (Technokroma C-18).

2.4 Chromatographic Conditions of RP-HPLC and Gas chromatography

All the experiments were performed on RP-HPLC and confirmed with gas chromatographs; the following conditions (Table 1) were adopted to identify and quantify the synthesised product.

3. RESULTS AND DISCUSSIONS

Experiments 1-12 were performed for selective nitration (at ortho and para positions) of phenols. Various electrophilic reagents and conditions were employed for these reactions commonly known as electrophilic aromatic substitutions. Table 2 shows important parameters for the nitration of concentrated phenol with nitric acid reagent (Experiments 1-3). Figure 1 displays the chromatogram of the nitration products of experiment 1. It was observed (Table 2) that *o/p* selectivity and %age conversion was lower in experiments 1-3. Moreover, the product yield was found to depend upon the reaction time. Four different peaks were observed in the chromatogram (Figure 1); the peaks at 2.630 and 4.489 minutes correspond to p-nitrophenol and o-nitrophenol, respectively as determined by analytical standards under the same conditions. However, the two peaks (1.202 and 1.418 minutes) observed very early on the left side of chromatogram were not verified; they definitely, belong to the formation of 2,4,6-trinitrophenol (picric acid) or other side product. The %age conversion of substrate to *o/p* isomers is influenced by these two peaks (on extreme left side of chromatogram); larger peaks will result in the less formation of desired isomers (ortho and para) and vice versa. The experiment 1 (Table 2) gives 33% conversion (p-nitro 18% and o-nitro 13%) within 30 minutes. This conversion was increased to 37% and 38% under the identical conditions by increasing the reaction time to 40 and

60 minutes, respectively.

The conversion of substrate phenol into *o/p* nitrophenols was also investigated by using dilute nitric acid (dilution was done with chilled water) at different temperatures (Tables 3-5). By using 50% nitric acid at various temperature (40°C, 30°C and 20°C with ±2°C), the overall yield of *o/p*-nitrophenols was increased to 55% (Table 3). Some phenol quantity was also left unreacted as observed from the chromatogram against working standards. Phenol has hydroxyl group which is more hydrophilic than the phenyl group, and as a result, the phenol remains in an interfacial state. This way, the phenolic ring's ortho position becomes activated at a specific temperature. This active site (ortho carbon atom) of the ringed structure can attack the nitronium ion more favorably as compared to the para position. However, other isomers such as di and tri-nitrophenols may also be synthesised as by-products during these reactions.

By varying the concentration of nitric acid solution to 40% and performing the experiments with the same quantity of phenol (5g of 98% phenol) at 40°C, 30°C and 20°C; the yields of *o/p* nitrophenols was increased to 54%, 66% and 72%, respectively (Table 4, experiments 7-9). Moreover, there was comparatively higher phenol consumption than the previous experiments, 4-6. The higher consumption of substrate ultimately enhanced the yield of end product i.e., nitrophenol. At 40°C, the initial peak was prominent in the chromatogram; this peak was reduced by lowering the reaction temperatures to 30°C and 20°C. The product yield was improved by lowering the temperature to 20°C (Exp. 7-9); a high yield with *o/p* of 72% was achieved at 20°C as compared to the 30°C and 40°C. It was concluded that low temperature is favorable for the conversion of phenol to para nitrophenol. While maintaining the importance of physical parameters during the reaction, the yield was increased by diluting nitric acid.

To improve selectivity of *o/p* nitrophenols, the strength of nitric was further reduced to 32.5% solution and experiments 10-12 were performed (Table 5); it increased the *o/p* conversion to 65%, 75% and 91% at temperatures of 40°C, 30°C and 20°C, respectively. Again, the decrease of temperature has resulted in the rise of nitrophenol yield. The *o/p* ratio was also significantly improved from 0.75 to 5.69 by lowering the temperature from 40°C to 20°C, respectively (Table 5). Overall, the selectivity of isomers was highly affected by internal temperature of the reaction

Table 1. Specific conditions for identification and quantification of synthesised product

RP-HPLC		GC	
Parameters	**Specifications**	**Parameters**	**Specifications**
Mobile phase	Acetonitrile: Water	Column	TRB-5
Proportion	40:60 (0.02M KH_2PO_4)	Dimension	30m x 0.25mm x 0.25µm
Flow	1.0 ml/min	Column Temperature	110°C
Injection volume	10µl	Inlet	Spilt injection (1:50)
Temperature	Ambient	Carrier gas:	Hydrogen/ Air
Wavelength	254 nm	Detector type	FID
Detector	UV-detector	Detector temperature	340°C

Table 2. Experimentations with concentrated materials

Exp. no	Phenol (98%) (g)	Nitric acid (65%) (g)	Reaction time	Conversion (%)	Selectivity (%)		
					o-nitro	*p-nitro*	*o/p ratio*
1	5.0	5.0	30 min	33	13	18	0.722
2	5.0	5.0	40 min	37	21	16	1.313
3	5.0	5.0	45 min	38	23	15	1.533

*__Reaction condition:__ substrate as concentrated phenol (98% purity) and nitric acid (65% purity)

as well as dilution of the nitrating agent. So, the current studies clarified that the strength of nitric acid strongly affects the conversion as well as selectivity of nitrophenol isomers. Figure 2 (A and B) displays the chromatograms for experiments 11 (at 30°C) and 12 (at 20°C). The results of experiment 12 are especially interesting. Here, the reaction mixture was agitated for one hour at 20°C and chromatographic study of the products mixture was performed by RP-HPLC. It was surprisingly noted that the nitrophenol conversion was 91% with 14% o-isomer and 77% (Table 5). It was concluded that this was a right economical process for the synthesis of nitrophenols by controlling the physical parameters during the course of reaction. The variation of the temperature may explicit the net conversion of phenol or phenolic compound. However, a very small amount of unreacted phenol was also noticed as initial peaks in the chromatograms of experiments 10-12 (Figure 2). Also, the intensity of these initial peaks (which may ultimately affect the net yield of the desired product) was reduced in the chromatogram in going from the experiment 11 (at 30°C, Figure 2A) to 12 (at 20°C, Figure 2B). In all of above experiments (1-12), the yields of the *o/p* nitrophenols were also calculated against pure analytical standards (having 99.9% purity). Figure 2 shows the chromatogram of high purity analytical standards of p-nitrophenol and o-nitrophenol. The analytical standards were also run on RP-HPPC under the same conditions as applied for experimental measurements.

Table 3. Experiments with 50% nitric acid strength (w/v)

Exp. No	Temp. of reaction mixture	Phenol (98%)	Dil. HNO_3 (50%)	Dilution scheme		Reaction time	Conversion	Selectivity (%)		
		(g)	(g)	Water (g)	65% N.A (g)	(min)	(%)	*ortho* nitro	*para* nitro	*o/p* ratio
4	40 °C	5	6.5	1.5	5	40	44	25	15	1.66
5	30 °C	5	6.5	1.5	5	40	50	33	17	1.94
6	20 °C	5	6.5	1.5	5	40	55	35	20	1.75

Table 4. Experiments with 40% nitric acid strength (w/v)

Exp. No.	Temp. of reaction mixture	Phenol (98%)	Dil. HNO_3 (40%)	Dilution scheme		Reaction time	Conversion	Selectivity (%)		
		(g)	(g)	Water (g)	65% N.A (g)	(min)	(%)	*ortho* nitro	*para* nitro	*o/p* ratio
7	40 °C	5	8.1	3.1	5	50	54	24	30	0.80
8	30 °C	5	8.1	3.1	5	50	66	32	34	0.94
9	20 °C	5	8.1	3.1	5	50	72	37	35	1.05

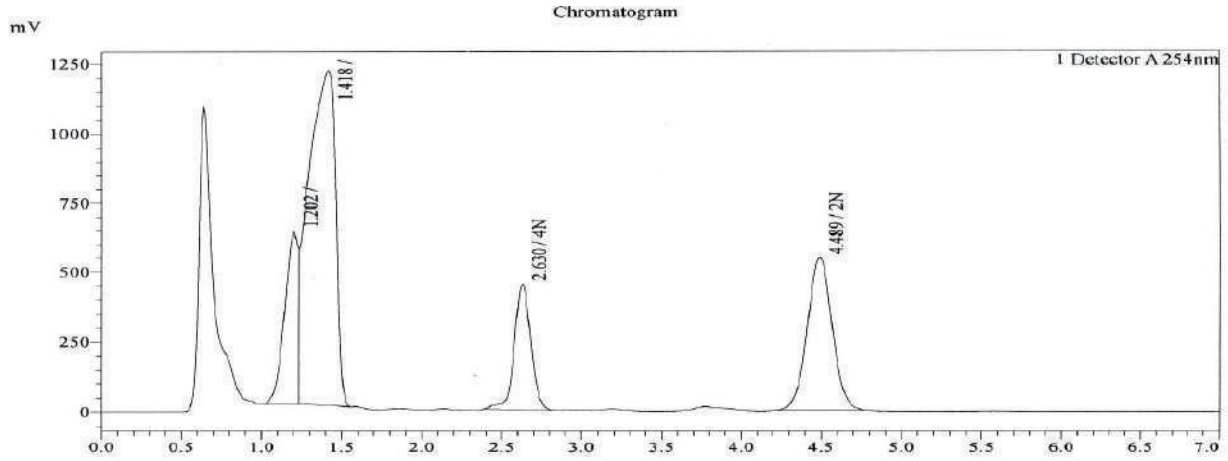

Fig. 1. Chromatogram for nitration of phenol with conc. nitric acid in 30 min (Exp 1)

Table 5. Experiments with 32.5% nitric acid strength (w/v)

Exp. No.	Temp. of reaction mixture (±2)	Phenol (98%)	Dil. HNO_3 (32.5%)	Dilution scheme		Reaction time	Conversion	Selectivity (%)		
		(g)	(g)	Water (g)	65% N.A (g)	(min)	(%)	*ortho* nitro	*para* nitro	*o/p* ratio
10	40 °C	5	10.8	5.8	5	1 hr	65	30	35	0.75
11	30 °C	5	10.8	5.8	5	1 hr	75	50	25	1.43
12	20 °C	5	10.8	5.8	5	1 hr	91	77	14	5.69

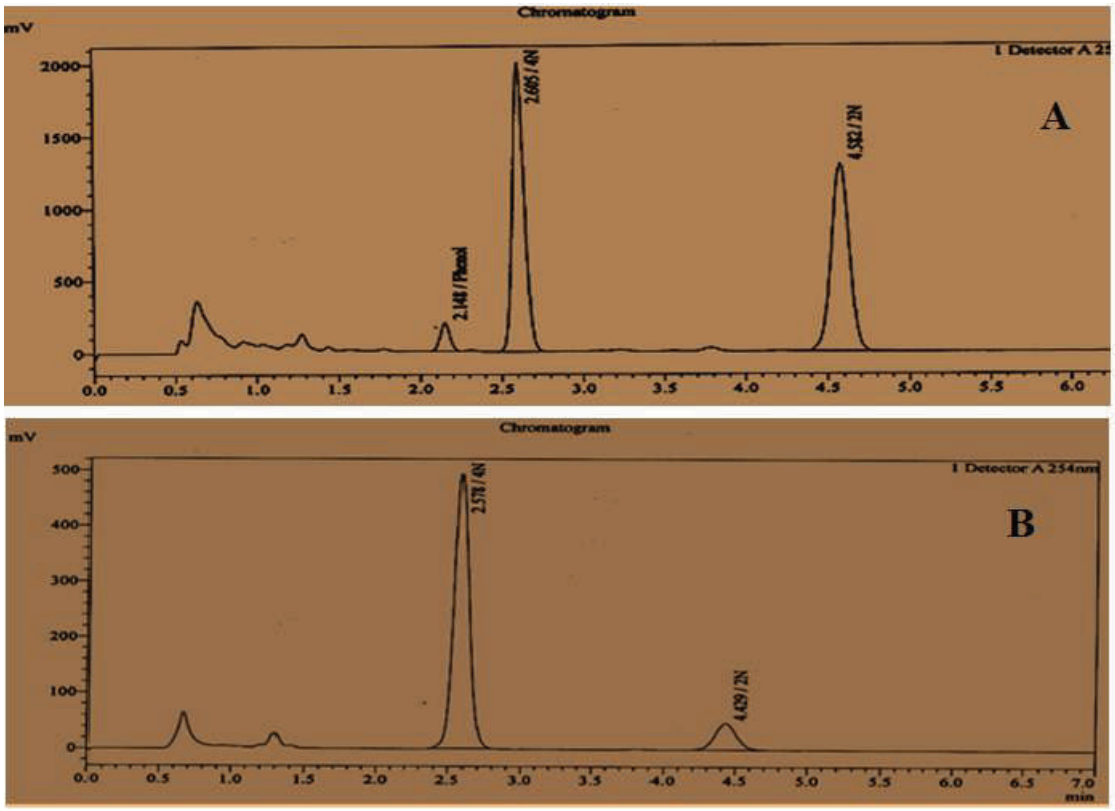

Fig. 2. (A-B): Chromatogram showing nitration of phenol with Dil. HNO_3 (32.5%) for 1 hr at 30°C (A) and 20°C (B)

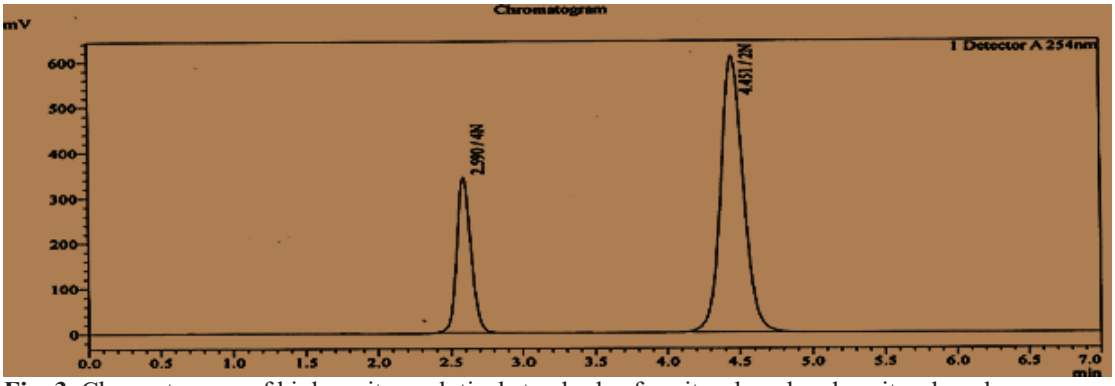

Fig. 3. Chromatogram of high purity analytical standards of *p*-nitrophenol and *o*-nitrophenol

As far as the regioselectivity is concerned, it was found through different experiments 1-12 that by lowering the temperature as well as the strength of nitric acid solution, the p-nitrophenol selectivity was increased because the nitronium ion attacks at the para position of the ring as the para position is far away from the hydroxyl group of ring. While at high temperature and high acid strength, it is very easy for nitronium ion to attack at ortho position of the ring structure. However, this selectivity may also be reversed by the use of catalysts i.e. CTAB, TBAB, NaBr etc as reported by different authors Chhatre et al [1993]. The selectivity of o-nitrophenol synthesis has been reported to be improved by carrying out the reaction under microemulsion conditions. It was suggested that the ratio of o-nitrophenol and p-nitrophenol is increased conversely with the decrease of initial phenol content. The solubility of phenol in the organic phase (isooctane) of microemulsion system is limited, and excess phenol is dissolved in the aqueous phase of microemulsion system. Apparently, the ratio of o-nitrophenol and p-nitrophenol is decreased [41]. It was suggested that the ratio of o-nitrophenol to p-nitrophenol was increased relatively when the concentration of HNO_3 was increased at constant concentration of phenol.

For comparison of results, the synthesis of nitrophenols was also investigated in the presence of smaller quantities of catalysts over substrate (phenol) and substituted phenol (4-chlorophenol); the obtained results are shown in Table 6 and Figures 4-6. In these experiments 13-15, H-β and γ-alumina (sigma Aldrich) catalysts were employed for selectivity and conversion of substrate (phenol) into *o/p* nitrophenols. The experiments were performed with dilute nitric acid and 0.50g catalyst quantity for 80 minutes reaction time at 24°C. It was concluded that there was good agreement for conversion of phenol to nitrophenol isomers with these catalysts. Also, it was noticed that both of the above discussed catalysts have characteristic potential for ortho-nitrophenol selectivity. With H-β catalyst (Table-6), there was 92% conversion with 78% o-nitrophenol and 14% para-nitrophenol selectivity. Similarly, with γ-alumina catalyst, there was overall conversion of 90% with 74% ortho-nitrophenol and 16% para-nitrophenol. Also, it was observed that conversion of substituted phenol into respective isomers was only 81% (Experiment 15, Table 6). No doubt, the catalysts play a very important role in the selectivity of isomers; however, comparing the results of experiments 13-15 with those of other experiments it can easily be understood that results of experiment 12 are much better. So, it can be concluded that raw materials and reaction conditions of experiment 12 are ideal, more environment friendly and more economical. Figure 7 displays the scheme for selected nitration reactions taking place in experiments 2, 6, 9 and 11-15 under various reaction conditions.

3.1 Factors affecting the synthesis and selectivity of nitrophenols

It was monitored through different experimentations that synthesis and selectivity of nitrophenol isomers was highly affected by dilution of nitric acid (Tables 2-5) and also in the presence/absence of catalysts (Table 6). When strength of nitric acid was increased from 32.5% to 65%, the conversion into *o/p* nitrophenol isomer was decreased from 91%, 75% and 65% (Table 5) into 38, 37 and 33 (Table 2) at temperatures of 20°C, 30°C and 40°C, respectively. By dilution of nitric acid from 65% to 50%, 40%, and 32.5%, the conversion of phenol to *o/p* nitrophenol was gradually increased (Tables 2-5). When 65% nitric acid was used for phenol nitration then di and tri-nitrophenol were also

Table 6. Synthesis of nitrophenols from phenol and substituted phenol in the presence of catalyst

Exp. No.	Substrate Used	Temp. of reaction mixture (±2)	Wt. of substrate	Dil. HNO_3 (32.5%)	Catalyst Used		Reaction time	Yield	Selectivity (%)		
			(g)	(g)	H-β (g)	γ-alumina (g)	(min)	(%)	*ortho* nitro	*para* nitro	*o/p* Ratio
13	Phenol	24°C	5	11	0.50	-	80	92	78	14	5.57
14	Phenol	24°C	5	11	-	0.50	80	90	74	16	4.69
15	4-chloro phenol	24°C	5	11	-	-	80	81	38	43	0.33

*Reaction conditions: Substrate phenol (5.0 gram); nitric acid (32.5%); temperature of reactions (24°C)

formed along with *o/p* nitrophenols. Experiments (No. 1-12) suggested that the nitric acid solution of 32.5% strength was the most suitable dilution for phenolic nitration as reflected from Figure 3 A & B. Figures 1 and 2 display the comparison between two chromatograms; one chromatogram (Figure 1) shows the effect of concentrated nitric acid on nitration while the other chromatogram (Figure 2) shows the effect of low temperature and dilute nitric acid on nitration of phenol.

3.2 Characterisation by Gas chromatography

The synthesised nitrophenols were characterised by gas chromatography. The *o/p*-nitrophenol standards with phenol substrate were employed with BHT (0.1%) solution as ISS (internal standard solution) for identification of the specific retention times of each isomer. The gas spectra with 32.5% nitric acid strength at 30°C and 20°C are displayed in Figures 8 and 9, respectively and corresponding data are summarised in Tables 7 and 8, respectively.

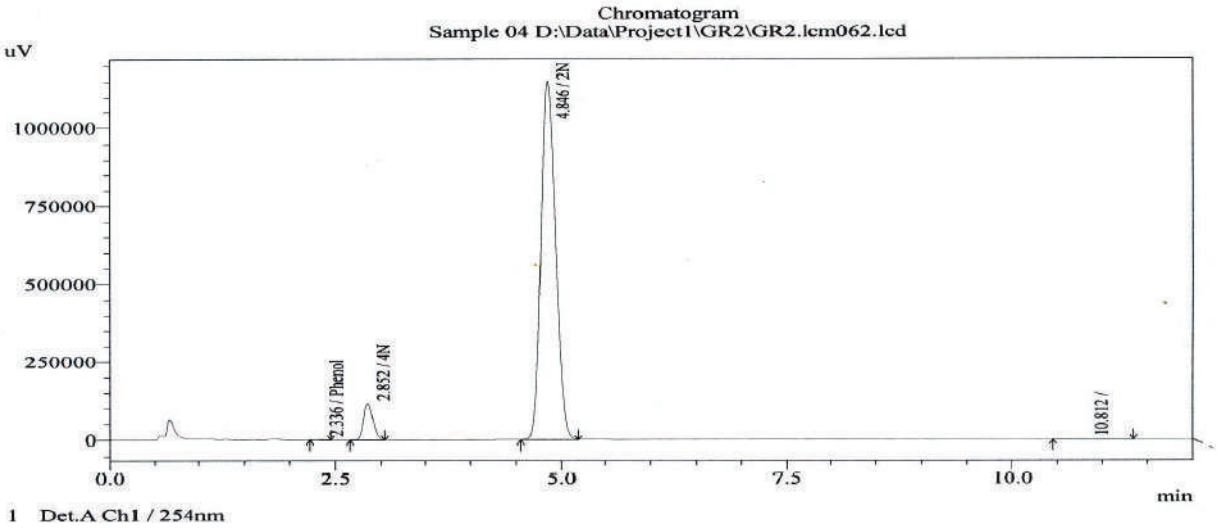

Fig. 4. Chromatogram for phenol nitration with 32.5% HNO_3 at 24°C in the presence of H-β

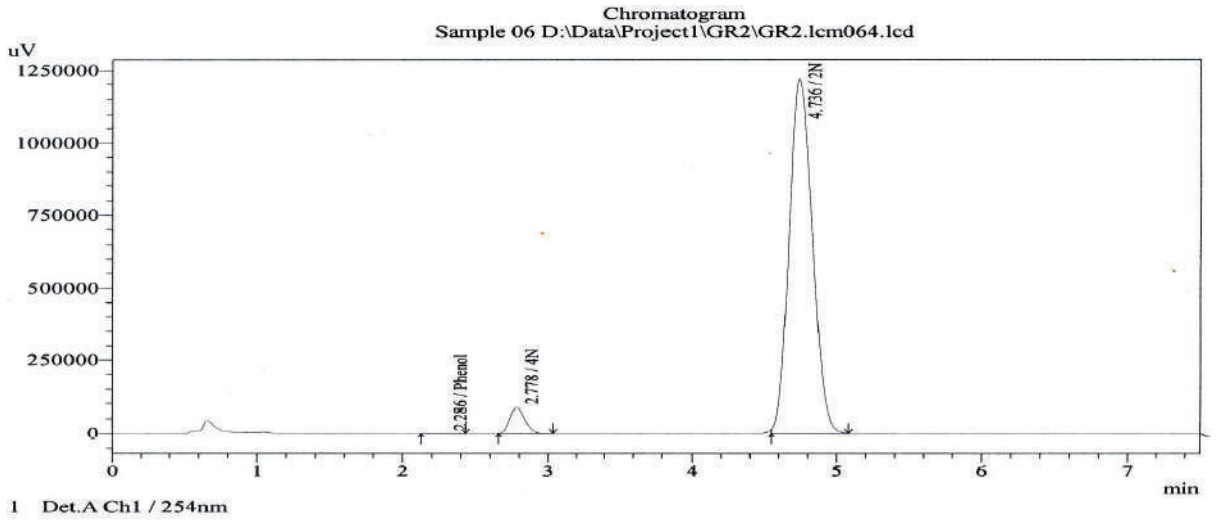

Fig. 5. Chromatogram for phenol nitration with 32.5% HNO_3 at 24°C in the presence of γ-alumina

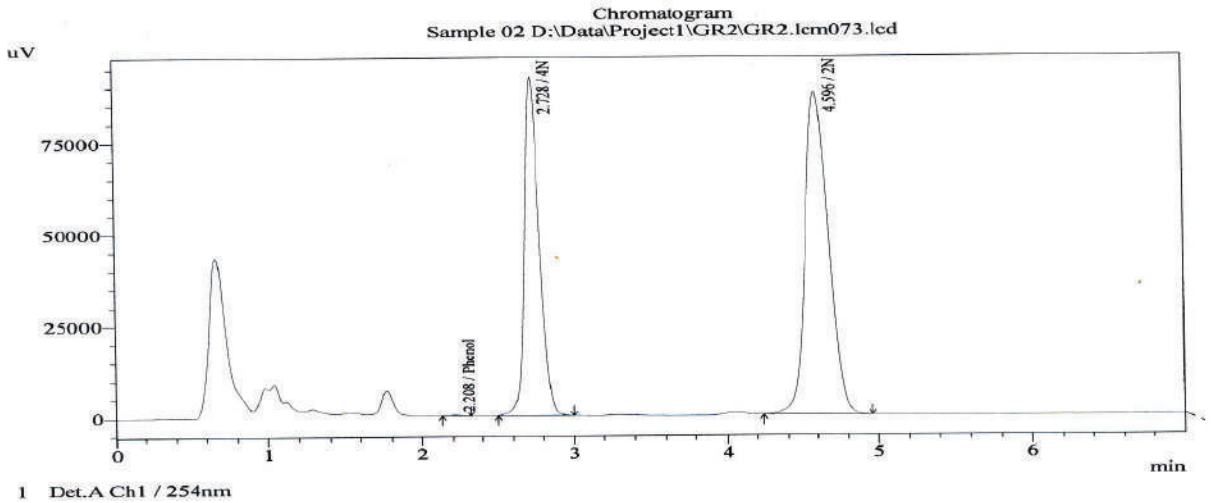

Fig. 6. Chromatogram for nitration of substituted phenol (4-chlorophenol) with 32.5% HNO_3 at 24°

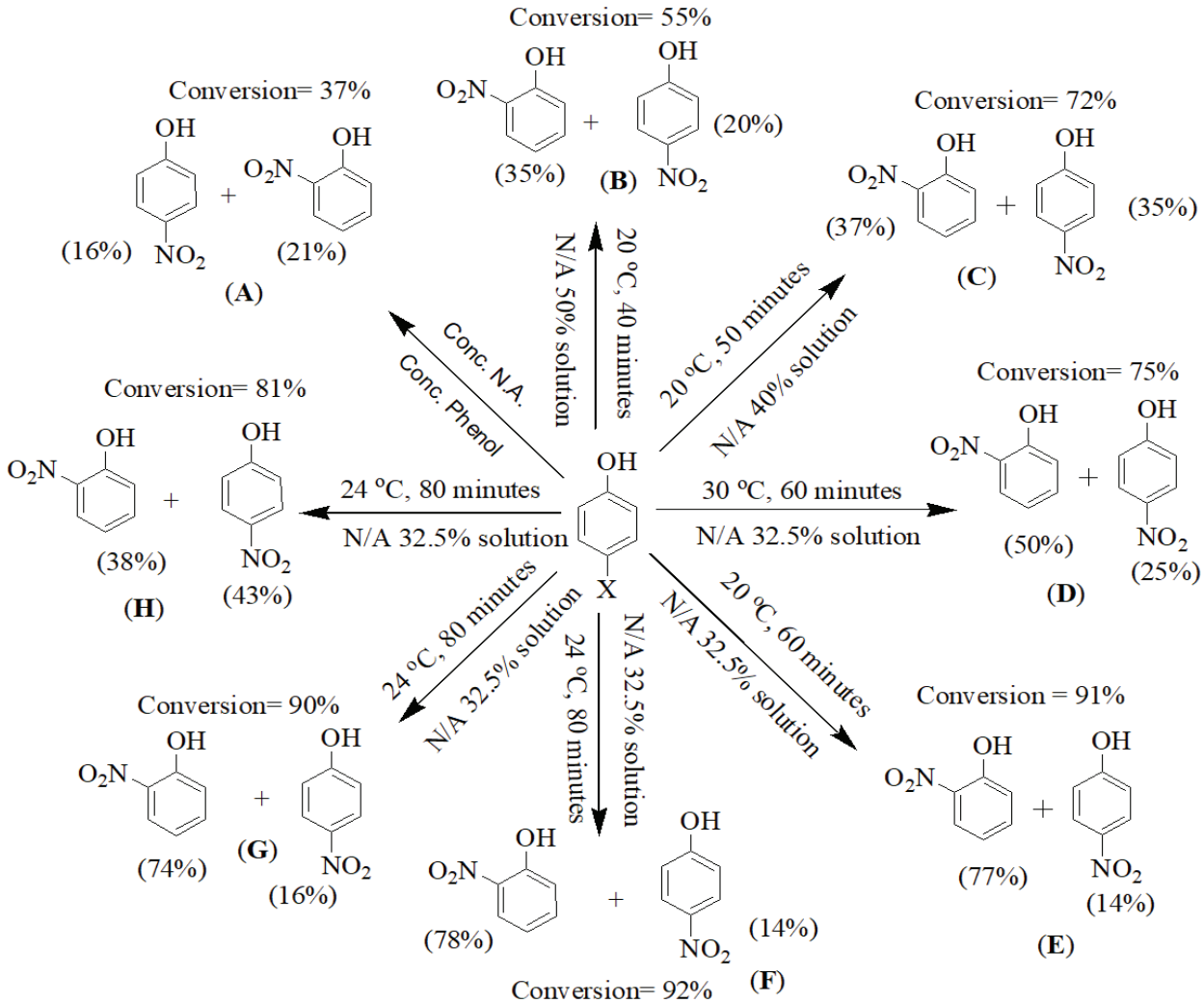

Fig. 7. Selective nitration reactions corresponding to experiments 2(**A**), 6(**B**), 9(**C**), 11(**D**), 12(**E**), 13(**F**), 14(**G**) and 15(**H**); X = H for experiments 1-14; X = Cl for experiment 15

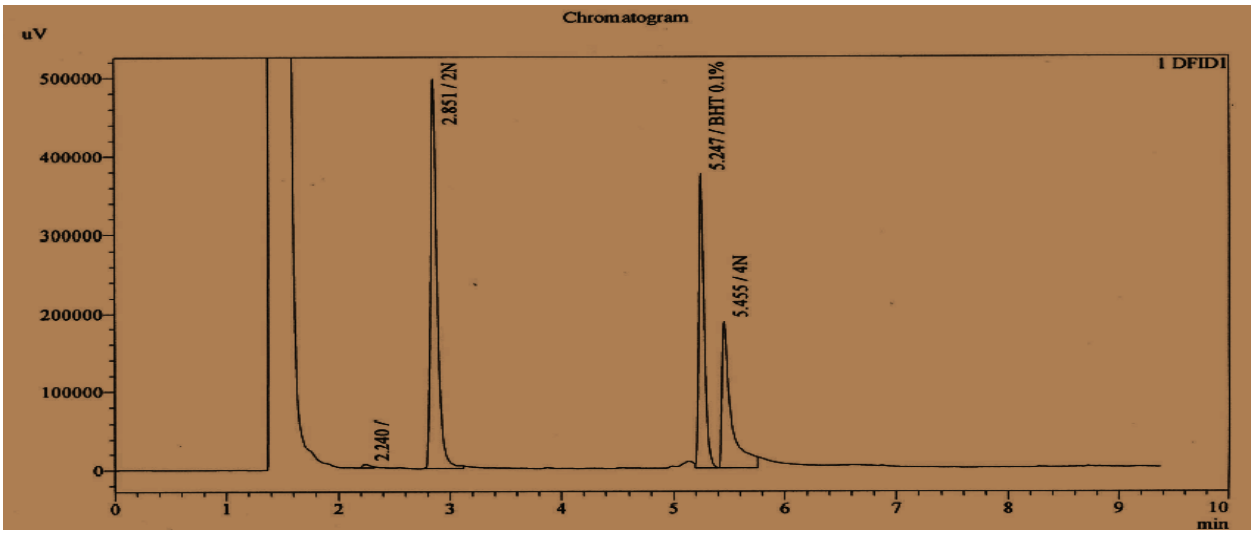

Fig. 8. GC Spectra (segregation peaks) with 32.5% nitric acid strength at 30°C

Table 7. Retention time and peak area (%) with GC capillary column using 32.5% nitric acid at 30°C

Sr. No	Retention time (minutes)	Substance	Peak area (%)
1	2.140	Phenol	7
2	2.851	*o*-nitrophenol	80
3	5.247	ISS (BHT 0.1%)	100
4	5.455	*p*-nitrophenol	13

Table 8. Retention time and peak area (%) with GC capillary column using 32.5% nitric acid at 20°C

Sr.No	Retention time (minutes)	Substance	Peak area (%)
1	2.105	Phenol	10
2	2.860	*o*-nitrophenol	15
3	5.263	ISS (BHT 0.1%)	100
4	5.525	*p*-nitrophenol	75

4. CONCLUSIONS

Phenol and its derivatives can selectively be nitrated into *o/p* nitrophenols by controlling only the physical parameters i.e., dilution of nitric acid, reaction time and reaction temperature. The reaction between 98% phenol and 32.5% nitric acid at a temperature of 20°C (±2°C) required only 1 hour for optimum (91%) yield of nitrophenols with 77% ortho and 14% para selectivity and was found most suitable route for economical production of nitrophenols. The investigated synthetic path is relatively clean and environmentally friendly as it does not involve catalysts and hazardous solvents, like the conventional processes. This process may be adopted for commercial production of nitrophenols which are plant growth regulators and are applied to crops for better agricultural production. The study discourages the use of costly surfactants such as (CTAB, TBAB, H-β and γ-alumina catalysts) which are traditionally used for commercial production of nitrophenols. This synthesis requires the lower number of chemicals, less time and does not involve the advance instruments.

5. CONFLICT OF INTEREST

There is no conflict of interest among the authors.

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Research Article

Close Form Solution for Dielectric Cylindrical Shell in Fractional Dimensional Space

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Abstract: We have studied the Laplacian equation in non-integer space which had been previously used to describe complex phenomena in physics and electromagnetism. We have applied this idea to a dielectric cylindrical shell to find the electric potential and field of a dielectric coated cylinder analytically in fractional dimensional space. The problem is derived using Gegenbauer polynomials. This close form gneral solution solved in fractional dimensional space can be applied for various materials of cylindrical shell, outside shell and inside the cylindrical core. The obtained solution is retrieved for integer order by setting the fractional parameter α=3.

Keywords: Fractional dimensional –Space, Laplacian-equation, Dielectric coated cylinder, Electric potential, Analytical Solution, Method of Separation Variables.

1. INTRODUCTION

MThe idea of non-integer space (FD space) is considered to be very useful in various areas of physics and electromagnetism and discussed by many researchers [1-19] and had applied it accordingly. Wilson [3] was the first who applied the non-integer space in quantum field theory.

Further, the non-integer space had been used as a parameter in the Ising limit of quantum field theory [6]. Stillinger [4] provided an axiomatic basis of this concept for the formulation of Schrodinger wave mechanics and Gibbsian statistical mechanics in the α-dimensional space. Svozil and Zeilinger [10] have presented the operationalistic definition of the dimension of space-time which has provided the possibility of experimental determination of the space-time dimension. It has also been stated that the non-integer dimension of space-time is slightly less than 4. In the new era, Gauss law [11] has been formulated in the α-dimensional fractional space. The solutions of electrostatic problems [13-18] have also been investigated in the FD space "$(2<\alpha\leq 3)$".

We have extended this problem from J.D. Jackson [13] exercise problem 4.8. The main focus is to use the Laplacian equation to find electric potential and field due to a dielectric cylindrical shell in FD Space. In this paper, the main focus is to use the Laplacian equation to find electric potential and field due to a dielectric cylinder in fractional space. Here the plan of the paper is to be described briefly. In Section 2, we have presented the mathematical model of the boundary value problem where a dielectric cylindrical shell is placed in a uniform electrical field. Then we elaborated potential of dielectric cylindrical shell by solving Laplacian equation to obtain the solution in FD space and constructed the solution for three different regions, namely outside shell, between shell and within the core of the cylinder. Lastly, the unknown constants are determined using boundary conditions and the electric potential and field for the regions in fractional space are derived. Final Section is devoted to our conclusions.

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2. MATHEMATICAL MODEL

We have considered an infinitely long circular cylindrical shell [13] of dielectric constant $\frac{\epsilon}{\epsilon_0}$ for which inside and outside radii are taken to be 'a' and 'b' respectively and are placed in uniform field E_0. The cylinder is oriented with its axis at the right angle to the applied primary field E_0. The medium within the interior cylinder and outside of the exterior cylinder has a dielectric constant of unity.

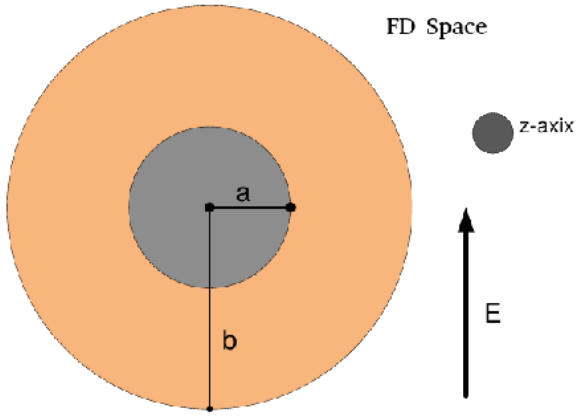

Fig. 1. Dielectric Cylindrical shell Placed in Fractional

We will find the potential and field in fractional space $2 < \alpha \leq 3$ in the three regions. We now employ the cylindrical coordinates (r, θ) for the appropriate solutions.

$$\nabla^2 \Psi(r, \theta) = 0 \qquad (1)$$

This is also known as the cylindrical wave equation

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial \Psi}{\partial}\right) + \frac{1}{r^2}\frac{\partial^2 \Psi}{\partial \phi^2} + \frac{\partial^2 \Psi}{\partial z^2} + k^2\Psi = 0 \qquad (2)$$

We will deal this problem in electrostatic and magnetostatics, where $\omega = 0$ so that k=0. Because of the translational symmetry of the problem along the z-axis, Ψ is independent of 'z' and we need only to consider the problem in the (r, θ)-plane. Furthermore, the symmetry in this problem leads us to choose cylindrical coordinates in which Poisson's equation is considered as follows,

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial \Psi}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 \Psi}{\partial \theta^2} = 0 \qquad (3)$$

The Eq(3) is solved by separable method and its possible solutions in the uniform field [17] are $r\cos\theta$ and $r^{-1}\cos\theta$.

The general solution of equation (3) can be expressed as

$$\Psi(r, \phi) = \sum_{l=0}^{\infty} \left(A_l r^l + B_l r^{-l}\right) P_l(\cos\theta) \qquad (4)$$

where, $P_1(\cos\theta) = \cos\theta$.

Eq(3) is solved by separable method in fractional space and suppose

$$\phi(r, \theta) = R(r)\Theta(\theta) \qquad (5)$$

The angular and radial differential equations are derived in [18] and [19] and are expressed as,

$$\left[\frac{d^2}{d\theta^2} + (\alpha - 2)\cot\theta\frac{d}{d\theta} + l(l + \alpha - 2)\right]\Theta(\theta) = 0 \qquad (6)$$

$$\left[\frac{d^2}{dr^2} + \frac{\alpha-2}{r}\frac{d}{dr} + \frac{l(l+\alpha-3)}{r^2}\right]R(r) = 0 \qquad (7)$$

The generalized solution of scalar potential of cylinder in fraction space is,

$$\Psi = \sum_{l=0}^{\infty} \left[a_l r^l + b_l r^{-(l+\alpha-3)}\right] P_l^{\alpha/2-1}(\cos\theta) \qquad (8)$$

On physical grounds, we can check and contain the derived form of the solution outside and inside the cylindrical region. Outside, we need to have the electric field at infinity, but we certainly do not want the field to diverge. The logarithmic and r^l with $l > 1$ terms diverge as 'r' goes to infinity. Clearly, these terms are unphysical. Therefore, we are interested only in the solution for $l = 1$, where $P_1^{\alpha/2-1}(\cos\theta) = (\alpha - 2)\cos\theta$. Because each region has the same symmetry with respect to the external field, so the expressions of the potentials in each region are expressed as follows,

we find the potetnial outside region,

$$\Psi(r, \phi) = \left(-E_0 r + A_1 r^{-(\alpha-2)}\right)(\alpha - 2)\cos\theta, \quad r > b \qquad (9)$$

In between the cylinders:

$$\Psi(r, \phi) = \left(B_1 r + C_1 r^{-(\alpha-2)}\right)(\alpha - 2)\cos\theta, \; a < r < b \qquad (10)$$

and In side the cylinder:

$$\Psi_1(r, \phi) = D_1 r(\alpha - 2)\cos\theta, \; 0 < r < a \qquad (11)$$

The boundary conditions at $r = a$ and $r = b$ are

$$\frac{\partial\Psi(r,\theta)}{\partial\theta}(b_-) = \frac{\partial\Psi(r,\theta)}{\partial\theta}(b_+) \quad (12)$$

$$\frac{\partial\Psi(r,\theta)}{\partial\theta}(a_-) = \frac{\partial\Psi(r,\theta)}{\partial\theta}(a_+) \quad (13)$$

$$\epsilon\frac{\partial\Psi(r,\theta)}{\partial r}(b_-) = \epsilon_0\frac{\partial\Psi(r,\theta)}{\partial r}(b_+) \quad (14)$$

and

$$\epsilon_0\frac{\partial\Psi(r,\theta)}{\partial r}(a_-) = \epsilon\frac{\partial\Psi(r,\theta)}{\partial r}(a_+) \quad (15)$$

From the above four boundary conditions, we obtain four equations in simplified form such that

$$A = E_0 b^{\alpha-1} + Bb^{\alpha-1} + C \quad (16)$$

$$a_1 A = -E_0 b^{\alpha-1} - \kappa B b^{\alpha-1} + a_1\kappa C \quad (17)$$

where $a_1 = (\alpha - 2)$ and $\kappa = \epsilon/\epsilon_0$

$$D = B + a^{-(\alpha-1)}C \quad (18)$$

$$D = \kappa\left(B - a_1 a^{-(\alpha-1)}C\right) \quad (19)$$

By solving Eq.(16) and Eq.(17) we eliminate the unknown coefficient A and obtain, the following expression

$$C = \frac{((a_1+)E_0 b^{\alpha-1}}{a_1(\kappa-1)} + \frac{(\kappa+a_1)b^{(\alpha-1)}}{a_1(\kappa-1)}B \quad (20)$$

Next we solve Eq.(18) and Eq.(19) to eliminate constant D and get

$$C = \frac{\kappa-1}{\kappa a_1+1}a^{-(\alpha-1)}B \quad (21)$$

Now we compare Eq.(20) and Eq.(21), and easily determine the unknown constant B

$$B = -\frac{(\alpha-1)(\kappa a_1+1)E_0 b^{(\alpha-1)}}{(\kappa+a_1)(\kappa a_1+1)b^{\alpha-1} - a_1(1-\kappa)^2 a^{\alpha-1}} \quad (22)$$

By substitution the value of the constant B in Eq.(22), we find the constant C

$$C = \frac{(\alpha-1)(1-\kappa)E_0 a^{(\alpha-1)}b^{(\alpha-1)}}{(\kappa+a_1)(\kappa a_1+1)b^{\alpha-1} - a_1(1-\kappa)^2 a^{\alpha-1}} \quad (23)$$

From Eq.(18), by substitution of B and C, we find the unknown constant D such that

$$D = -\frac{(\alpha-1)(\alpha-1)E_0 b^{(\alpha-1)}}{(\kappa+a_1)(\kappa a_1+1)b^{\alpha-1} - a_1(1-\kappa)^2 a^{\alpha-1}} \quad (24)$$

Next we substitute the value of B and C in Eq.(16) and obtain the unknown constant A

$$A = E_0 b^{(\alpha-1)} + \frac{(1-\kappa)a^{(\alpha-1)} - (1+\kappa a_1)b^{(\alpha-1)}}{(\kappa+a_1)(\kappa a_1+1)b^{\alpha-1} - a_1(1-\kappa)^2 a^{\alpha-1}} \quad (25)$$

Now we retrieve the exact solution [13] by setting $\alpha = 3$ and $a_1 = (\alpha - 2)$, that is given below:

$$B = -\frac{2E_0 b^2(1+\kappa)}{b^2(1+\kappa)^2 - a^2(1-\kappa)^2} \quad (26)$$

By substitution the value of the constant B in Eq.(22), we find the constant C

$$C = \frac{2E_0 a^2 b^2(1-\kappa)}{b^2(1+\kappa)^2 - a^2(1-\kappa)^2} \quad (27)$$

From Eq.(18), by substitution of B and C, we find the unknown constant D such that

$$D = -\frac{4E_0 b^2}{b^2(1+\kappa)^2 - a^2(1-\kappa)^2} \quad (28)$$

Next we substitute the value of B and C in Eq.(16) and obtain the unknown constant A

$$A = E_0 b^2 + 2E_0 b^2 \frac{a^2(1-\kappa) - b^2(1+\kappa)}{b^2(1+\kappa)^2 - a^2(1-\kappa)^2} \quad (29)$$

Special Cases

(1): For a dielectric cylinder, If we the inner radius of the cylinder decreases to zero, that is, $a \to 0$, we get the solution such that In FD Space

$$A = \frac{\kappa-1}{\kappa+1}E_0 b^{\alpha-1} \quad (30)$$

In Integer order

$$A = \frac{\kappa-1}{\kappa+1}E_0 b^2,\ for\ \alpha = 3 \quad (31)$$

In FD Space

$$B = \frac{-(\alpha-1)E_0}{\kappa+1},\ for\ \alpha = 3 \quad (32)$$

In Integer order

$$B = \frac{-2E_0}{\kappa+1},\ for\ \alpha = 3 \quad (33)$$

$$C = 0 \quad (34)$$

In FD Space

$$D = \frac{-(\alpha-1)(\alpha-1)E_0}{(\kappa+1)^2} \quad (35)$$

$$D = \frac{-4E_0}{(\kappa+1)^2},\ for\ \alpha = 3 \quad (36)$$

(2) For the cylindrical cavity, we place the surface of the outer shell at infinity, $b \to \infty$, In this case A is ill-defined, so we would not ignore it.

$$B = \frac{-(\alpha-1)E_0}{\kappa+1} \tag{37}$$

$$B = \frac{-2E_0}{\kappa+1},\ for\ \alpha = 3 \tag{38}$$

In FD Space

$$C = (\alpha-1)E_0 a^{\alpha-1}\frac{1-\kappa}{(1+\kappa)^2} \tag{39}$$

$$C = 2E_0 a^2 \frac{1-\kappa}{(1+\kappa)^2},\ for\ \alpha = 3 \tag{40}$$

In FD Space ,

$$D = \frac{-(\alpha-1)(\alpha-1)E_0}{(1+\kappa)^2} \tag{41}$$

$$D = \frac{-4E_0}{(1+\kappa)^2},\ for\ \alpha = 3 \tag{42}$$

3. CONCLUSION

In this paper the Laplacian equation has been studied in $\boldsymbol{\alpha}$-dimensional non-integer space. The expressions of potentials and electric fields of the dielectric cylindrical shell are obtained in non-integer space. The classical results are recovered from the investigated solution for $\boldsymbol{\alpha = 3}$. Further, this solution can be applied for various materials. The host medium and core medium can be studied for multiple materials like meta-materials, plasma etc.

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5. CONFLICT OF INTEREST

There is no conflict of interest among the authors.

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Research Article

Design of Fractional Order Sliding Mode Adaptive Fuzzy Switching Controllers for Uncertain ACP1000 Nuclear Reactor Dynamics

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Abstract: Advanced Chinese Pressurized Water Reactor (ACP1000) is a third generation load following nuclear reactor. ACP1000 is designed to control the reactor power by a sophisticated control rod mechanism under the base load normal operation of a nuclear power plant in Mode-G. To extend the normal operation of ACP1000 for load following condition, boron adjustment control is used in manual configuration. In this research work, model based two new controllers are designed for ACP1000 reactor dynamics. A nonlinear two-point reactor kinetics model is developed for two halves of the reactor core designated as top and bottom of reactor core. Reactor feedbacks model for two-point reactor kinetics model is developed with fuel temperature, moderator temperature, Xenon concentration, G-Bank control rod position, R-Bank control rod position and boron concentration feedbacks under normal operation of ACP1000. Two problems of the large reactor core of ACP1000 are Xenon oscillations and axial offset in core power distribution. To address these problems, two new controllers are designed for normal load following operation of ACP1000. One controller is designed to replace G1-Bank and R-Bank in Mode-G for reactor power control. The second controller is designed to replace G2-Bank in Mode-G for reactivity control and axial power distribution control. Originally, both reactor coolant average temperature controller and reactor power controller were adaptive controllers. Therefore, both new controllers are designed based on an optimized sliding algorithm using a dedicated fractional order sliding mode control oriented adaptive fuzzy logic control (FO-SMC-AFLC) synthesis scheme. The performance of the proposed closed loop controllers is evaluated for design step and ramp power transients. Both proposed controllers are validated against benchmark results reported in Preliminary Safety Analysis Report (PSAR) of ACP1000. The novel control design scheme is proved satisfactory for normal load following operation of ACP1000, and all the results are found well within design limits.

Keywords: ACP1000, G and R-Banks, Reactor Dynamics, Fractional Order, Sliding Mode Control, Adaptive Fuzzy Logic

1. INTRODUCTION

In this research work, modeling and control design of Advanced Chinese Pressurized Water Reactor of 1100 MWe rating (ACP1000) based nuclear power plant is attempted.

The design and safety aspects of ACP1000 nuclear power plant are presented in [1-3]. The reactor dynamics and its original reactor power controller design aspects are covered in [4], while the controller design algorithm in mode-G under load following operation is presented in [5]. A research is conducted for adaptive fuzzy controller design for fractional order MIMO system with input saturation in [6]. A fractional order adaptive fuzzy controller is designed for uncertain robotic manipulators in [7]. An adaptive fuzzy sliding mode controller is designed for parallel manipulator with parametric uncertainties in [8]. An adaptive fuzzy

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fractional sliding mode controller is synthesized for nonlinear multivariable system in [9]. A research work is explored in the direction of designing an adaptive fuzzy fractional sliding mode control for antilock braking system in [10]. An adaptive fractional order fuzzy sliding mode controller is made in designing the fractional order fuzzy sliding mode control for knee joint orthosis in [11]. An adaptive fractional order sliding mode fuzzy controller is designed for active power filter in [12]. The research is further extended with an adaptive back stepping fractional fuzzy sliding mode controller design for an active power filter in [13]. Robust fuzzy adaptive sliding mode controller is developed for fractional order chaos in [14]. A research is further extended for adaptive fuzzy fractional order sliding mode controller design for uncertain system in [15]. A two-point reactor kinetic model is developed for PWR and a load following axial offset LQG/LTR controller is designed in [16]. A fuzzy fractional PID controller is designed for PWR in [17]. Simulate-3K neutronic and thermal hydraulic modeling aspects are presented in [18].

In ACP1000 reactor dynamics, G-bank is designed for reactor power control and coolant temperature control, while R-bank is designed for reactor power control purposes. Two point reactor kinetics model (2PRKM) with feedbacks of G-bank and R-bank control rods (GR) and liquid poison as chemical shim dynamics (CSD) are integrated as 2PRKM-GR-CSD. In this research work, a two-point reactor kinetic model of ACP1000 with special emphasis on G-bank, R-bank and chemical shim dynamics (2PRKM-GR-CSD) is modelled for the first time, and a novel optimized fractional order sliding adaptive fuzzy logic algorithm is developed for reactivity control, axial power distribution control and hence reactor power control. The proposed control design structure for 2PRKM-GR-CSD is a Fractional Order Sliding Mode Control Adaptive Fuzzy Logic Controller (FO-SMC-AFLC).

2. MATERIALS AND METHODS

2.1 ACP1000 Reactor Dynamics

The reactor core of ACP1000 is large and therefore is modelled with two-point reactor kinetics (2PRKM) models. Top half reactor core is modelled by one PRKM and bottom half core is modelled by second PRKM. Neutron and precursor dynamics are represented by PRKM with six precursor groups. Since there are two PRKM, so both models are strongly coupled. Internal reactor dynamics is covered with fuel temperature dynamics (FTD), moderator temperature dynamics (MTD) and Xenon concentration dynamics (XCD), while external reactor dynamics is covered with control rod dynamics (CRD) and boron concentration dynamics (BCD). In ACP1000, Mode-G is used for temperature and reactor power control using G-bank and R-bank known as GR dynamics (GRD). G-bank consists of sub G1-bank and sub G2-bank while R-bank is a single bank. G-bank has more worth than R-bank because it is meant for temperature control and reactor power control, while R-bank is meant for power control only. Control rods are configured in Rod Control Cluster Assembly (RCCA) in a reactor core. The boron concentration dynamics is known as Chemical Shim Dynamics (CSD). The entire behaviour of 2PRKM, FTD, MTD, XCD, GRD and CSD is known as reactor dynamics of ACP1000. Axial offset is a more severe control problem than Xenon Oscillations because it covers the control rod dynamics with more reactivity worth.

2.2 Two-Point Reactor Kinetics Model of ACP1000

The top half reactor core is modelled by the top point reactor kinetic model for relative neutron power (Prt) as [16]:

$$\frac{dP_{rt}(t)}{dt} = \frac{\rho_t(t)-\beta}{\Lambda_t} P_{rt}(t) + \sum_{i=1}^{6} \lambda_i C_i(t) - P_{rbt}(t) \quad (1)$$

$$\frac{dC_{ti}(t)}{dt} = \frac{\beta_i}{\Lambda_t} P_{rt}(t) - \lambda_i C_{ti}(t) \quad (2)$$

Where the symbols have their usual meanings.

The bottom half reactor core is modelled by bottom point reactor kinetic model for relative neutron power (P_{rb}) as:

$$\frac{dP_{rb}(t)}{dt} = \frac{\rho_b(t)-\beta}{\Lambda_b} P_{rb}(t) + \sum_{i=1}^{6} \lambda_i C_i(t) - P_{rtb}(t) \quad (3)$$

$$\frac{dC_{bi}(t)}{dt} = \frac{\beta_i}{\Lambda_b} P_{rb}(t) - \lambda_i C_{bi}(t) \quad (4)$$

Where the symbols have their usual meanings.

The reactor core total relative power is given as:

$$P_r(t) = P_{rt}(t) + P_{rb}(t)$$

P_{rtb} and P_{rbt} are computed through a coupling coefficient as:

$$P_{rtb}(t) = \alpha(P_{rt}(t) - \frac{P_{b0}}{P_{to}} P_{rb}(t)) \quad (5)$$

$$P_{rbt}(t) = \alpha(P_{rb}(t) - \frac{P_{t0}}{P_{bo}} P_{rt}(t)) \quad (6)$$

Where α is the coupling coefficient.

The thermal hydraulics model is composed of FTD and MTD.

The top fuel temperature dynamics are given as:

$$\frac{dT_{ft}(t)}{dt} = \frac{P_{rt}(t)}{M_{ft}C_f} - \frac{(T_{ft}(t) - T_{ct}(t))}{R} \quad (7)$$

$$\frac{dT_{ct}(t)}{dt} = \frac{(T_{ft}(t) - T_{ct}(t))}{RM_{ct}C_{Pc}} - 2W_{ct}C_{pc}(T_{ct}(t) - T_{\text{int}}(t)) \quad (8)$$

The bottom fuel temperature dynamics is given as:

$$\frac{dT_{fb}(t)}{dt} = \frac{P_{rb}(t)}{M_{fb}C_f} - \frac{(T_{fb}(t) - T_{cb}(t))}{R} \quad (9)$$

$$\frac{dT_{cb}(t)}{dt} = \frac{(T_{fb}(t) - T_{cb}(t))}{RM_{cb}C_{Pc}} - 2W_{cb}C_{pc}(T_{cb} - T_{inb}) \quad (10)$$

The decay heat is used to calculate fuel and moderator temperatures. Therefore, 4th order coupled decay heat model is developed.

Where the symbols having their usual meanings.

The top Iodine concentration dynamics are given as:

$$\frac{dI_t(t)}{dt} = Y_{It}P_{rt}(t) - \lambda_{It}I_t(t) \quad (11)$$

The top Xenon concentration dynamics are given as:

$$\frac{dX_t(t)}{dt} = (3.12\times10^{10})\frac{Y_{Xt}}{V_t\Sigma_f}P_{rt}(t) - \lambda_{Xt}X_t(t) + \lambda_{It}X_t(t) - \sigma_X X_t(t)P_{rt}(t) \quad (12)$$

The bottom Iodine concentration dynamics is given as:

$$\frac{dI_b(t)}{dt} = Y_{Ib}P_{rb}(t) - \lambda_{Ib}I_b(t) \quad (13)$$

The bottom Xenon concentration dynamics is given as:

$$\frac{dX_b(t)}{dt} = (3.12\times10^{10})\frac{Y_{Xb}}{V_b\Sigma_f}P_{rb}(t) - \lambda_{Xb}X_b(t) + \lambda_{Ib}X_b(t) - \sigma_X X_b(t)P_{rb}(t) \quad (14)$$

Where the symbols having their usual meanings.
The top control rod G1-bank and R-bank reactivity is given as:

$$\frac{d\rho_{crt}(t)}{dt} = G_t r_t(t) + G_b r_b(t) \quad (15)$$

Where

$$G_t = f_t(G_{G1}^{PartLength}, G_{G2}^{PartLength}, G_R^{PartLength}) \quad (16)$$

$$r_t(t) = g_t(r_{G1}^{PartLength}(t), r_{G2}^{PartLength}(t), r_R^{PartLength}(t)) \quad (17)$$

$$G_b = f_b(G_{G1}^{FullLength}, G_{G2}^{FullLength}, G_R^{FullLength}) \quad (18)$$

$$r_b(t) = g_b(r_{G1}^{FullLength}(t), r_{G2}^{FullLength}(t), r_R^{FullLength}(t)) \quad (19)$$

The bottom control rod G1-bank and R-bank reactivity is given as:

$$\frac{d\rho_{crb}(t)}{dt} = G_b r_b(t) \quad (20)$$

The boron reactivity is given as:

$$\frac{d\rho_b(t)}{dt} = \Psi_b(\kappa_b, V, \Sigma_f, \sigma_b, N_W)b(t)P_r(t) \quad (21)$$

Where the symbols have their usual meanings.

2.3 ACP1000 Reactivity Feedbacks Model

The top reactivity is given as:

The top reactivity is given as:

$$\rho_t(t) = \alpha_f(T_{ft}(t) - T_{ft0}) + \alpha_c(T_{ct}(t) - T_{ct0}) - \rho_b(t) + \rho_{crt}(t) - \frac{\sigma_{aX}}{\nu\Sigma_f}(X_t(t) - X_{t0}) \quad (23)$$

The bottom reactivity is given as:

$$\rho_b(t) = \alpha_f(T_{fb}(t) - T_{fb0}) + \alpha_c(T_{cb}(t) - T_{cb0}) - \rho_b(t) + \rho_{crb}(t) - \frac{\sigma_{aX}}{\nu\Sigma_f}(X_b(t) - X_{b0}) \quad (24)$$

$$\rho_{cr}(t) = \rho_{crt}(t) + \rho_{crb}(t)$$

Where the symbols have their usual meanings.

2.4 State-Space Model Development of ACP1000 Reactor Dynamics

Nonlinear equations (1) to (4), equations (7) to (15) and equations (20) to (22) are linearized by a small perturbation method using the following equation:

$$x(t) = x_0 + \delta x(t)$$

The framework of the linearized ACP1000 reactor core model is shown in Fig. 1.

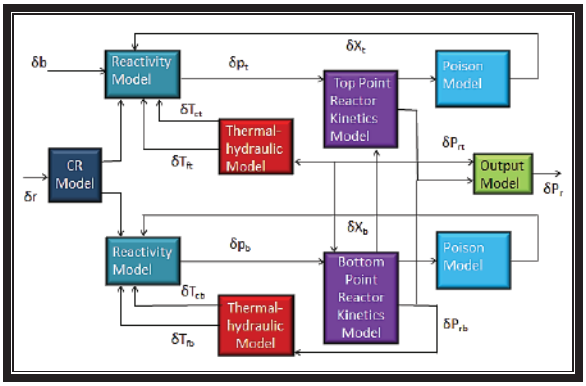

Fig. 1. Framework for Linearized ACP1000 reactor core model.

The linearized 26th order Multi-Input Multi-Output (MIMO) model is represented in state space form as:

$$\dot{x}(t) = A_{m\times m}x_{m\times 1}(t) + B_{m\times n}u_{n\times 1}(t) \quad (25)$$

$$y(t) = C_{p\times m}x_{m\times 1}(t) \quad (26)$$

Where u(t) and y(t) are the input and output vectors and defined as:

$$u(t) = [r_t \;\; r_b \;\; b]^T$$

$$y(t) = [P_{rt} \;\; P_{rb}]^T$$

Now the 26th order linearized MIMO model is decoupled into six SISO models using the transfer matrix in frequency domain as:

$$G(s) = \frac{Y(s)}{U(s)}$$

$$\begin{bmatrix} Y_1(s) \\ Y_2(s) \end{bmatrix} = \begin{bmatrix} G_{11}(s) & G_{12}(s) & G_{13}(s) \\ G_{21}(s) & G_{22}(s) & G_{23}(s) \end{bmatrix} \begin{bmatrix} U_1(s) \\ U_2(s) \\ U_3(s) \end{bmatrix} \quad (27)$$

Of six SISO sub-systems, four are of prime concern.

2.5 Parametric Uncertainties in ACP1000 Reactor Dynamics

The neutronic parametric uncertainties of ACP1000 reactor dynamics is accessed by using SIMULATE-3, which is an advanced transient nodal coupled neutronic thermal-hydraulic code, and the following parameters are found best estimated values with nominal values and parametric uncertainties:

$$\bar{\alpha}_f = \alpha_f \pm \Delta\alpha_f$$

$$\bar{\alpha}_c = \alpha_c \pm \Delta\alpha_c$$

$$\bar{\rho}_{G1} = \rho_{G1} \pm \Delta\rho_{G1}$$

$$\bar{\rho}_{G2} = \rho_{G2} \pm \Delta\rho_{G2}$$

$$\bar{\rho}_R = \rho_R \pm \Delta\rho_R$$

$$\bar{b} = b \pm \Delta b$$

Now equations (25) and (26) are revised as:

$$\dot{\bar{x}}(t) = (A + \Delta A)\bar{x}(t) + (B + \Delta B)u(t) \quad (27)$$

$$y(t) = (C + \Delta C)\bar{x}(t) \quad (28)$$

Equations (27) and (28) are rewritten as:

$$\dot{\bar{x}}(t) = \overline{A}\bar{x}(t) + \overline{B}u(t) \quad (29)$$

$$y(t) = \overline{C}\bar{x}(t) \quad (30)$$

2.5 FO-SMC-AFLC Controller Synthesis

2.5.1 Framework of FO-SMC-AFLC

Since in the original design, both reactor coolant average temperature controller and reactor power controller are adaptive in nature. Therefore, both new controllers are synthesized using an optimized sliding algorithm which mimics novel hybrid fractional order sliding surface and adaptive fuzzy scheme. Hence, it is the best novel design approach for the replacement of existing controllers with state-of-the-art novel controllers. The basic structure of the hybrid Fractional Order (FO), Sliding Mode Control (SMC) and Adaptive Fuzzy Logic Controller (AFLC) is shown in Fig. 2.

The inputs, outputs and interface of each FO, SMC and AFLC are very much obvious in Fig. 2. The concept of adaptation is also shown along with AFLC. This basic concept is adopted for the synthesis of two main and four sub-controllers.

2.5.2 Closed Loop Configuration of FO-SMC-AFLC Controller for ACP1000 Reactor Dynamics

Based on the framework of FO-SMC-AFLC presented in Fig. 2, the two advanced controllers are designed for reactor power control using G1-bank and R-bank designated as (FO-SMC-AFLC-1) and reactor power control using G2-bank, reactivity control and axial power distribution control designated as FO-SMC-AFLC-2 respectively. FO-SMC-AFLC-1 is further divided into two sub-controllers for control rod reactivity control designated as FO-SMC-AFLCr1) and boron reactivity control designated as FO-SMC-AFLCb1 respectively. Similarly, FO-SMC-AFLC-2 is

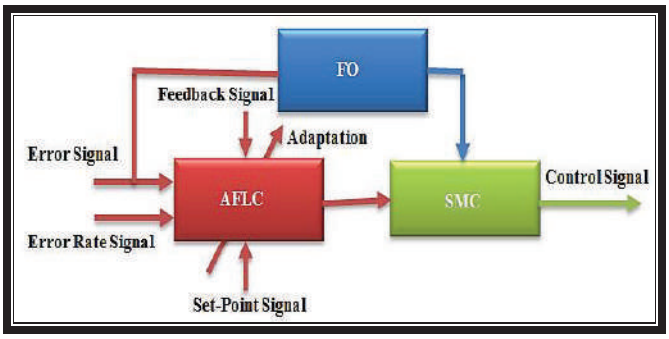

Fig. 2. Internal framework of FO-SMC-AFLC.

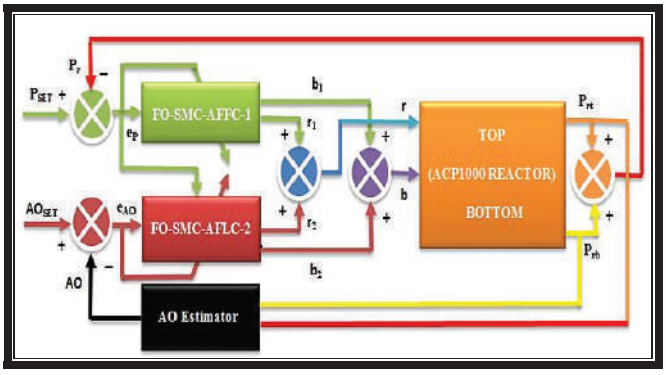

Fig. 3. Closed loop configuration of fractional order sliding mode adaptive fuzzy logic switching controllers for ACP1000 reactor dynamics.

further divided into two sub-controllers for control rod reactivity control designated as FO-SMC-AFLCr2 and boron reactivity control designated as FO-SMC-AFLCb2. The closed loop configuration of fractional order sliding mode adaptive fuzzy logic switching controllers for ACP1000 reactor dynamics is shown in Fig. 3.

The output of FO-SMC-AFLC-1 and FO-SMC-AFLC-2 are given as:

$$r(t) = r_1(t) + r_2(t) \tag{31}$$

$$b(t) = b_1(t) + b_2(t) \tag{32}$$

The output of AO estimator is given as:

$$AO(t) = \frac{P_{rt}(t) - P_{bt}(t)}{P_{rt}(t) + P_{bt}(t)} \tag{33}$$

The error signals for FO-SMC-AFLC-1 and FO-SMC-AFLC-2 are given as:

$$e_P(t) = P_{SET}(t) - P_r(t) \tag{34}$$

$$e_{AO}(t) = AO_{SET}(t) - AO(t) \tag{35}$$

The error rate signals for FO-SMC-AFLC-1 and FO-SMC-AFLC-2 are given as:

$$\dot{e}_P(t) = \frac{d(P_{SET}(t) - P_r(t))}{dt} \tag{36}$$

$$\dot{e}_{AO}(t) = \frac{d(AO_{SET}(t) - AO(t))}{dt} \tag{37}$$

Now, the outputs of two sub-controllers FO-SMC-AFLCr$_1$ and FO-SMC-AFLCb$_1$ are given as:

$$r_1(t) = \Psi_{r_1}(e_P(t), \dot{e}_P(t), FO_{r_1}, SMC_{r_1}, AFLC_{r_1}) \tag{38}$$

$$b_1(t) = \Psi_{b_1}(e_P(t), \dot{e}_P(t), FO_{b_1}, SMC_{b_1}, AFLC_{b_1}) \tag{39}$$

Now, the outputs of two sub-controllers FO-SMC-AFLCr$_2$ and FO-SMC-AFLCb$_2$ are given as:

$$r_2(t) = \Psi_{r_2}(e_P(t), e_{AO}(t), \dot{e}_P(t), \dot{e}_{AO}(t) FO_{r_2}, SMC_{r_2}, AFLC_{r_2}) \tag{40}$$

$$b_2(t) = \Psi_{b_2}(e_P(t), e_{AO}(t), \dot{e}_P(t), \dot{e}_{AO}(t) FO_{b_2}, SMC_{b_2}, AFLC_{b_2}) \tag{41}$$

Now, based on equation (29), equation (27) is redefined in time domain as a function of and t. State space model of top relative reactor power to top control rod reactivity is given as:

$$\dot{\bar{x}}(t) = f_{11}(\bar{x}, t) + \overline{B}_{f_{11}} u_1(t) \tag{42}$$

$$y_1(t) = \overline{C}_{f_{11}} \bar{x}(t) \tag{43}$$

State space model of top relative reactor power to boron reactivity is given as:

$$\dot{\bar{x}}(t) = f_{13}(\bar{x}, t) + \overline{B}_{f_{13}} u_3(t) \tag{44}$$

$$y_1(t) = \overline{C}_{f_{13}} \bar{x}(t) \tag{45}$$

State space model of bottom relative reactor power to bottom control rod reactivity is given as:

$$\dot{\bar{x}}(t) = f_{22}(\bar{x}, t) + \overline{B}_{f_{22}} u_2(t) \tag{46}$$

$$y_2(t) = \overline{C}_{f_{22}} \bar{x}(t) \tag{47}$$

State space model of bottom relative reactor power to boron reactivity is given as:

$$\dot{\bar{x}}(t) = f_{23}(\bar{x}, t) + \overline{B}_{f_{23}} u_3(t) \tag{48}$$

$$y_2(t) = \overline{C}_{f_{23}} \bar{x}(t) \tag{49}$$

Now sliding mode controller is structured for FO-SMC-AFLCr$_1$, FO-SMC-AFLCb$_1$, FO-SMC-AFLCr$_2$ and FO-SMC-AFLCb$_2$.

If η_l is the fractional order of derivative function $D^{\eta}{}_l$ then fractional order sliding mode controllers for all four sub-controllers are defined and modelled as [15]:

$$u_{11}(t) = u^F_{eq_{11}}(t) + K_{SMC_{11}}(D^{\eta}{}_1 e_p(t) + k_{11} e_p(t)) \tag{50}$$

Where k_{11} is the design parameter of function f11(.) and computed as:

$$\phi(r_1(x_{Position})) = k_{11} x_{Position} \tag{51}$$

$$\frac{d\phi(r_1(x_{Position}))}{dx_{Position}} = k_{11} \tag{52}$$

KSMC11 is the design gain and given as:

$$K_{SMC_{11}} = (k_{11} B_{f_{11}})^{-1} T \tag{53}$$

Where T is the positive definite matrix.

The equivalent controller with filter is given as:

$$u_{eq_{11}}^{F}(t)=\frac{1}{1+\tau_{F_{11}}s}u_{eq_{11}}(t) \tag{54}$$

Where τ_{F11} is the filter for high frequency components in control signal and s is the sliding surface defined as:

$$s=\{r_1:\theta(\bar{x},t)=0\}$$

Where $\theta(\bar{x},t)\approx\theta(x,t)$ is the sliding function and computed as:

$$\theta(\bar{x},t)=k_{11}(P_{SET}-r_1)=\Psi_\theta(\phi(x),\varphi(t))$$

The equivalent controller without filter is given as:

$$u_{eq_{11}}(t)=\frac{1}{k_{11}}\frac{d\varphi(t)}{dt}-f_{11}(\bar{x},t)$$

Similarly, rest of three FO-SMC for $f_{13}(.), f_{22}(.)$ and $f_{23}(.)$ are modeled as:

$$u_{13}(t)=u_{eq_{13}}(t)+K_{SMC_{13}}(D^{\eta_2}e_p(t)+k_{13}e_p(t)) \tag{55}$$

$$u_{22}(t)=u_{eq_{22}}(t)+K_{SMC_{22}}(D^{\eta_3}e_{AO}(t)+k_{22}e_p(t)) \tag{56}$$

$$u_{23}(t)=u_{eq_{23}}(t)+K_{SMC_{23}}(D^{\eta_4}e_{AO}(t)+k_{23}e_p(t)) \tag{57}$$

Now, the adaptive fuzzy logic controllers are structured based on the closed loop FO-SMC driven outputs, generated from ACP1000 reactor dynamics as outputs P_{rt}(t) and P_{rb} (t) respectively and one extracted signal as AO (t).

If $r_1(k)$ is LV^j , where LV^j is the j-th linguistic variable with j-th membership function (j) then j-th rule (R_j) is computed at k-th instant as:

$$R_j(k)=K_{IN11_j}P_{SET}(k)+K_{OUT11_j}r_1(k) \tag{58}$$

Where K_{IN1Ij} and K_{OUTIIj} are the input and output gains and are computed as:

$$K_{IN11_j}=\frac{a_j-0.1}{b_j} \tag{59}$$

$$K_{OUT11_j}=\frac{0.1-a_j+b_jK_{IN11_j}}{b_j}$$

Where aj and bj are the design scalar parameters of j-th membership function.

Now, the output of j-th adaptive fuzzy logic controller is given as:

$$u_{AFLC11}(k)=a_jR_j(k)+b_j(K_{IN11_j}P_{SET}(k)-K_{OUT11_j}r_1(k)) \tag{59}$$

Now, the value of k11 is rewritten as:

$$k_{11}=u_{AFLC11}(k) \tag{60}$$

The final control law is computed by substituting the value of k11 from equation (60) into equation (50) as:

$$u_{11}(t)=u_{eq_{11}}^{F}(t)+K_{SMC_{11}}(D^{\eta_1}e_p(t)+u_{AFLC11}e_p(t)) \tag{61}$$

Similarly, equations (53), (54) and (55) are updated as:

$$u_{13}(t)=u_{eq_{13}}^{F}(t)+K_{SMC_{13}}(D^{\eta_2}e_p(t)+u_{AFLC13}e_p(t)) \tag{62}$$

$$u_{22}(t)=u_{eq_{22}}^{F}(t)+K_{SMC_{22}}(D^{\eta_3}e_{AO}(t)+u_{AFLC22}e_p(t)) \tag{63}$$

$$u_{23}(t)=u_{eq_{23}}^{F}(t)+K_{SMC_{23}}(D^{\eta_4}e_{AO}(t)+u_{AFLC23}e_p(t)) \tag{64}$$

Now, equations (32) and (33) are rewritten as:

$$r(t)=r_1(t)+r_2(t)=u_{11}(t)+u_{13}(t) \tag{65}$$

$$b(t)=b_1(t)+b_2(t)=u_{22}(t)+u_{23}(t) \tag{66}$$

3. RESULTS AND DISCUSSIONS

EThere are six SISO sub-systems of 2PRKM-GR-CSD model. The behaviour of open loop and closed loop systems are evaluated in the following sections. All the modelling, design, simulation and analysis are carried out in a MATLAB environment.

3.1 Evaluation of 2PRKM-GR-CSD Model in Open Loop

The design parameters of open loop model are computed and optimized using a SIMULATE-3 neutronic and thermal-hydraulic code [18] which are tabulated for uncertain 2PRKM-GR-SCD model shown in Table 1.

Table 1. Optimized parameters of 2PRKM-GR-SCD

Design Parameters	Design Values
α	0.5
$\Delta\alpha_F$ (pcm/K)	±3.5
$\Delta\alpha_C$ (pcm/K)	±3.3
$\Delta\alpha_{G1}$ (pcm)	±42.5
$\Delta\alpha_{G2}$ (pcm)	±78.2
$\Delta\alpha_R$ (pcm)	±105.4
Δb (ppm)	±48
$m \times m$	26×26
$m \times n$	26×3
$p \times m$	2×26

In this research work, the pole-zero map of the model from top relative power to top control rod reactivity represented by equations (42) and (43) is shown in Fig. 4.

The presence of poles and zeros in the right half of S-plane shown in Fig. 4 proves that the sub-system is unstable. The open loop unit step response of this sub-system is shown in Fig. 5.

The open loop response shown in Fig. 5 clearly shows that the dynamics of the sub-system is unstable.

Similarly, the open loop response of other three sub-systems of interest is investigated and found unstable. The unstable dynamics is made stable through proper designing of sub-controllers.

3.2 Evaluation of FO-SMC-AFLC in Closed Loop

The closed loop evaluation of FO-SMC-AFLC-1 and FO-SMC-AFLC-2 is performed in Simulink. All the equations (1) through (66) are programmed and shown in the simulation model in Fig. 6.

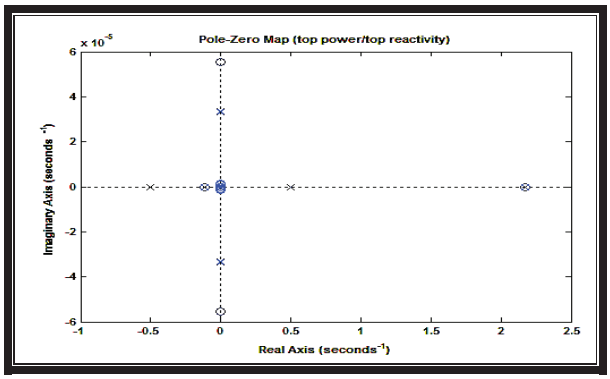

Fig. 4. Pole-Zero map of model from top relative power to top control rod reactivity.

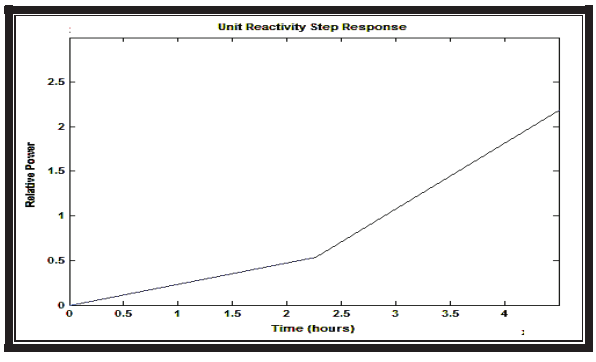

Fig. 5. Open loop unit step response of model from top relative power to top control rod reactivity.

The dynamic simulation is performed and assessed using two types of transient simulations. One is ramp transient, and the second is step transient simulation experiments.

The benchmark is the Preliminary Safety Analysis Report (PSAR) containing the results of the original reactor power control system with G-bank and R-bank. The redesigned proposed reactor power control system is designated as FO-SMC-AFLC.

The controller design constraints [4] are tabulated in Table 2.

The optimized design parameters of FO-SMC-AFLC-1 and FO-SMC-AFLC-2 are tabulated in Table 3.

3.2..1 Ramp Transient Simulations

In ramp power transient, the reactor power is increased from 40% to 50% at a rate of 5%/hr and then the reactor power is decreased from 50% to 30% at rate of 10%/hr. This ramp-up and ramp-down power sequence is followed in the transient analysis as per load following the procedure laid down in the design. The behaviour of FO-SMC-AFLC based closed loop system is shown in Fig. 7 against the desired ramp reference signal.

Table 2. Controller design constraints

Parameters	Value
Maximum Overshoot (%)	13
Settling Time (Sec)	900
AO band	$\pm$0.05
Step Power change rate (%)	10
Ramp Power change rate (%/min)	5

Table 3. Design parameters of FO-SMC-AFLC-1 and FO-SMC-AFLC-2

Design Parameters	Design Values
η_1	0.72
η_2	0.78
η_3	0.83
η_4	0.86
K_{SMC11}	1.8
K_{SMC13}	2.2
K_{SMC22}	4.3
K_{SMC23}	5.2
Value of j for FO-SMC-AFLCr_1	15
Value of j for FO-SMC-AFLCb_1	13
Value of j for FO-SMC-AFLCr_2	9
Value of j for FO-SMC-AFLCb_2	7
Scalar design parameters of FO-SMC-AFLC1	28
Scalar design parameters of FO-SMC-AFLC2	16

It is very much obvious from Fig. 7 that the relative reactor power tracks well the target ramp reactor power.

The performance of proposed control system for top and bottom halves of reactor core for ramp transient is shown in Fig. 8 and Fig. 9, respectively.

It is very much obvious from Fig. 7 that the relative reactor power tracks well the target ramp reactor power.

Top control rod reactivity with full and part length control rods, is computed and compared with benchmark results [1]. At the start of transient, when power is increased, the control rods are withdrawn due to which its reactivity becomes less negative. At constant power level, it remains almost constant. At the end of transient, when power is decreased from 50 % to 30%, the reactivity again becomes more negative.

Similar behaviour is observed for bottom control rod reactivity with only full length control rods in Fig. 9 and is computed and compared with benchmark results [1]. It includes full length control rods due to which the effect of reactivity is less as compared to top reactivity with the power manoeuvrings.

The performance of the proposed controller in terms of overshoot and settling time for ramp power changes are well within the designed constraints.
The variation of axial offset is shown in Fig. 10.

The performance of the proposed controller in terms of AO band for ramp power changes is well within the designed target band of □0.05.
The variation of boron concentration is shown in Fig. 11.

The output of second controller FO-SMC-AFLC-2 is the boron concentration which is computed

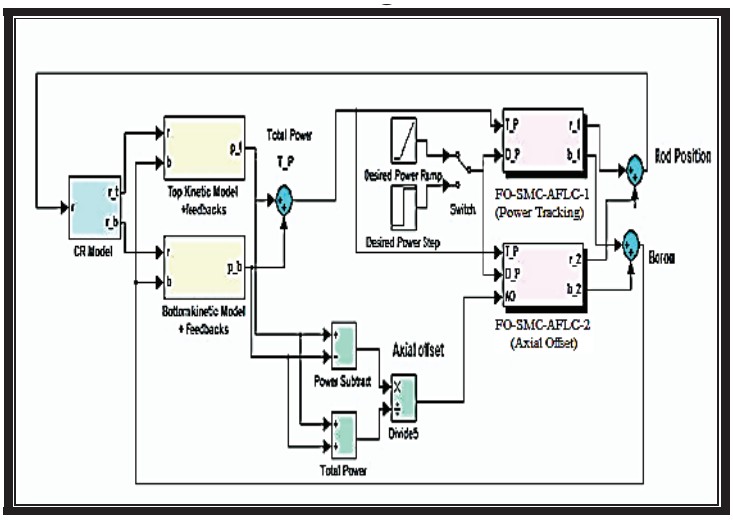

Fig. 6. Reactor power control redesign logic with two PRKM and AO for ACP1000.

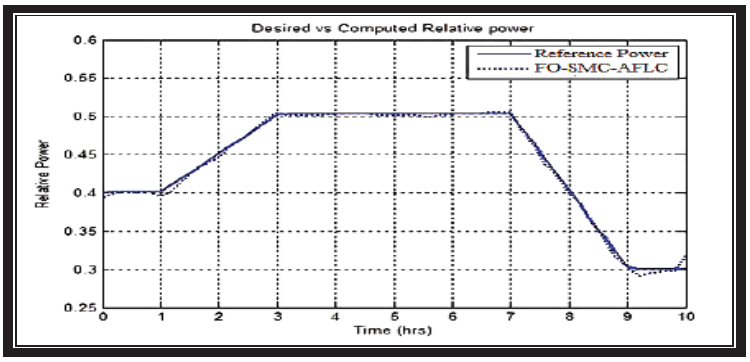

Fig. 7. Comparison of FO-SMC-AFLC and reference reactor powers under ramp power changes.

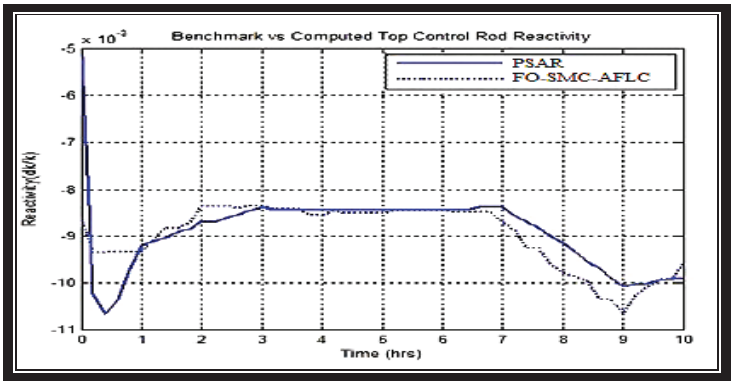

Fig. 8. Performance comparison of top control rod reactivity for ramp power changes.

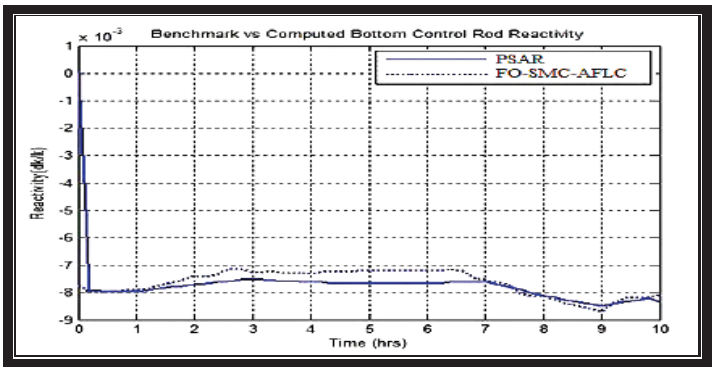

Fig. 9. Performance comparison of bottom control rod reactivity for ramp power changes.

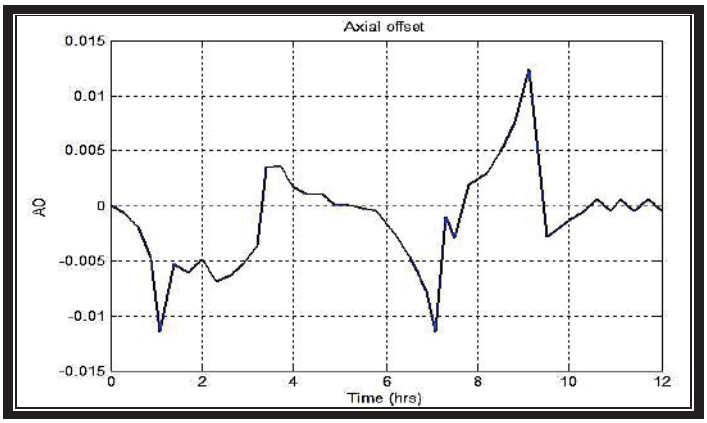

Fig. 10. Variation of axial offset for ramp power changes.

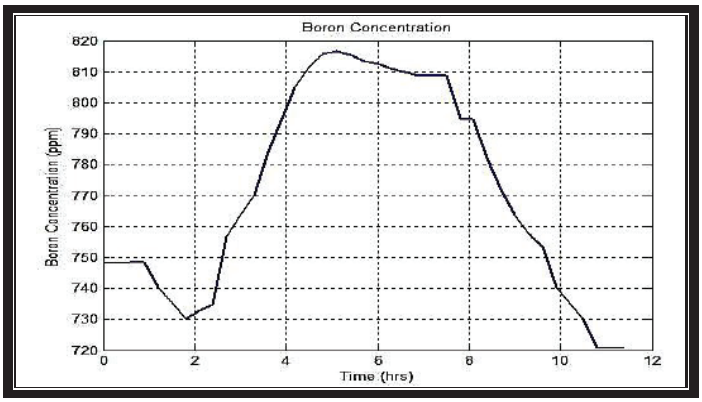

Fig. 11. Variation of boron concentration for ramp power changes.

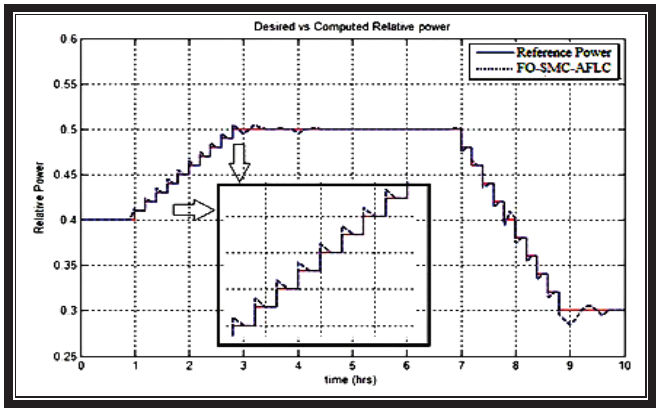

Fig. 12. Comparison of FO-SMC-AFLC and reference reactor powers under step power changes.

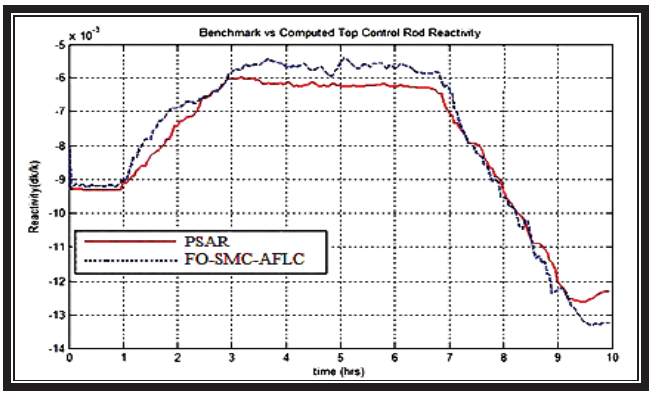

Fig. 13. Performance comparison of top control rod reactivity for step power changes.

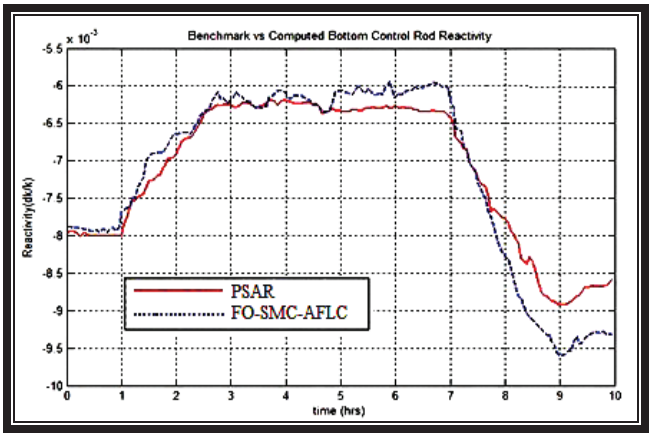

Fig. 14. Performance comparison of bottom control rod reactivity for step power changes.

and shown in Fig. 11. As the reactor power is increased, the boron concentration is diluted but with the passage of time, the xenon concentration is decreased as the reactor power increases. Therefore, to compensate the Xenon dynamics, the boration is accomplished.

3.2.2 Step Transient Simulations

In step power transient, the reactor power is increased from 40% to 50% with 1% power change rate and then the reactor power is decreased from 50% to 30% with 2% power change rate. This is a step change procedure which is adopted in ACP1000 nuclear reactor dynamics. The behaviour of FO-SMC-AFLC based closed loop system is shown in Fig. 12 against the desired step reference signal.

It is very much obvious from Fig. 12 that the relative reactor power tracks well the target step reactor power.

The performance of proposed control system for top and bottom halves of reactor core for step transient is shown in Fig. 13 and Fig. 14, respectively.

The reasons for top and bottom reactivity variations with relative step power are similar as that of ramp power changes.

The performance of the proposed controller in terms of overshoot and settling time for step power changes are well within the designed constraints.

The variations of axial offset and boron concentration are shown in Fig. 15 and Fig. 16 respectively. The performance of the proposed controller in terms of AO band for ramp power changes is well within the designed target band of 0.05. The reasons of boron and Xenon reactivity compensation with step power changes are similar as that of ramp power changes.

4. CONCLUSIONS

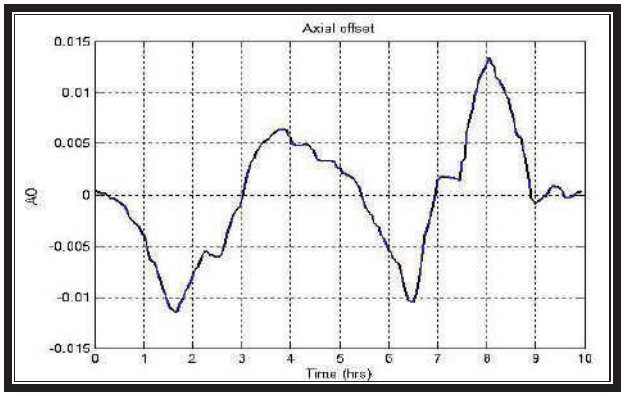

Fig. 15. Variation of axial offset for step power changes.

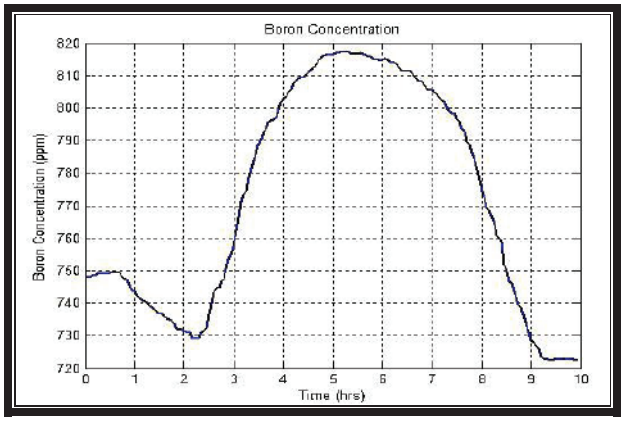

Fig. 16. Variation of boron concentration for step power changes.

wo-point kinetics model of ACP1000 reactor has been developed and reactivity feedbacks have been modeled with special emphasis on G-bank, R-bank RCCA and chemical shim for load following operation. A three input, two output highly nonlinear 26th order MIMO model of ACP1000 reactor dynamics has been developed. MIMO model is decoupled into desired SISO sub-systems. Large reactor core neutronic problems of ACP1000 have been addressed and successfully solved. Two state-of-the-art new controllers have been configured for reactor power compensation, reactivity control and axial power distribution control using most advanced optimized sliding control design algorithms. Both controllers have two SISO sub-controllers for control rod position and boron concentration. Modelling, control design, optimization, simulation and analysis have been accomplished in the MATLAB environment. Transient simulation experiments show that successful realization has been achieved. The extension of research work for other control rod banks with other modes of operations of ACP1000 is straightforward in future.

5. ACKNOWLEDGEMENTS

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6. CONFLICT OF INTEREST

There is no conflict of interest among the authors.

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Research Article

Anatomy of Sentiment Analysis of Tweets Using Machine Learning Approach

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Abstract: Sentiment Analysis (SA) is an efficient way of determining people's opinions from a piece of text. SA using different social media sites such as Twitter has achieved tremendous results. Twitter is an online social media platform that contains a massive amount of data. The platform is known as an information channel corresponding to different sites and categories. Tweets are most often publicly accessible with very few limitations and security options available. Twitter also has powerful tools to enhance the utility of Twitter and a powerful search system to make publicly accessible the recently posted tweets by keyword. As popular social media, Twitter has the potential for interconnectivity of information, reviews, updates, and all of which are important to engage the targeted population. In this work, numerous methods that perform a classification of tweet sentiment on Twitter have been discussed. There has been an extensive research studies in the field of SA of Twitter data. This study provides a comprehensive analysis of the most standard and widely applicable opinion mining techniques based on machine learning and lexicon-based along with their metrics. The proposed work is helpful in informaiton analysis in the tweets where opinions are found heterogeneous, unstructured, polarised negative, positive, or neutral. In order to validate the supremacy of the suggested approach, we have executed a series of experiments on the real-world Twitter dataset that alters to show the effectiveness of the proposed framework. This research effort also highlighted the recent challenges in the SA field and the proposed work's future scope. .

Keywords: Sentiment analysis, Opinion Mining, Social Media, Social Network Analysis, Sentiment Aspects Extraction, Twitter, Machine Learning

1. INTRODUCTION

The usage of the internet, particularly social media and microblogging sites is the hallmark of today's 4G's and 5G's age. At the moment blogs, online forums, reviews, websites, and media platforms are considered to be the most usable platforms, where someone can share and express their feelings. Millions of people make use of social network sites like Facebook, Twitter, and Google to express their emotions, points of view, and views about their everyday lifestyle [1]. Twitter is considered one of the most significant and vibrant Online Social media today. Twitter has more than 650 million registered users and it is commonly ranked as one of the most popular online social networking web site, although practically, it is the third most popular after the Instagram and Facebook [2]. Through online groups, one can easily join media where consumers notify and bias something through the forums [1,3]. Due to the vast usage of social media forums, it has been observed that a huge volume of sentiment-rich data within the realm of tweets, status upgrades, blog publish, remarks, and reviews are being generated at every movement. Moreover, social media gives a chance to various stakeholders such as businesses by giving a floor to connect with their customers for advertising and dealings [3]. Common people, on the whole, may also utilise the online user-created content to the best length for decision making. Similarly, if someone needs to buy a product or wants to use any service, they can easily get it by discussing it on social media forums before concluding [4]. There exists a huge amount of content that is openly available on different

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forums in the form of reviews and comments that helps marketers and firms to realise their products and assist them to improve their products as per the user's need [5-7].

The research community tries to utilise these reviews, opinions and comments based on textual data to make the right decision quickly and to analyse people's views about anything [8].

With their large-scale repositories of user-generated content, online social network services can provide unique opportunities to gain insights into the spiritual "pulse of the nation" and truly the global society. The collection of relative information from such unformed textual information and then analyses is quite a complex and hectic task [9]. There are a huge number of social networking websites that allow users to contribute, improve, and grade the content, it also shows their thinking about particular topics such as adding blogs, forums, product evaluation sites, and social networks, like Twitter [10- 11].

Numerous review, analysis, and textual information improvement techniques are mainly exclusive in the transform, easily to search and effectively analyse the data. Many such techniques focus on facts with objective items, but other textual content expresses subjective attributes [12]. These contents are mainly outlook, sentiments, estimation, attitudes, and emotions, which form the core of Sentiment Analysis (SA).

The fast development in the domain of SA has resulted in large number of different classifications and taxonomies, such as orientation (negative, positive, neutral) and attitude (affect, judgment, appreciation), etc [53-54]. SA is a subfield of natural processing that offers different challenging prospects to evolve new applications, mainly due to the massive progression of accessible information on online sources like blogs and social networks. SA acts as a recommendation system of a thing proposed by a guidance system to forecast it either positive or negative. Research on SA has studied almost all the main features like data collection, feature extraction, analysis, and recommendations. Besides that, a well-studied sub-problem of SA is opinion grouping on dissimilar granularity. But in different ways, current solutions are still far from perfect, and there is still a lack to address manyy issues with optimal solutions [13]. Based on current evolution, it is trusted that it needs to behave more in-depth and clarified investigations pointing at multimodal sentiment analysis (MSA).

Contribution of the Paper: This research study provides a summary of recent experimentation of various modes separately and jointly to explore the flaws in terms of theories, approaches, tasks and applications. So far, most of the SA research studies are supported conversation processing and linguistics. These established works specialised in textual content, while people progressively cash in on videos, images, and audio to air their opinions on social media networks[14] Thus, it is highly significant to subject to the work's opinions and identifies sentiments from various modalities. However, the sector of multimodal sentiment analysis has not received much attention and few state-of-the-art methods exist in MSA. Where the size of such state-of-the-art frameworks believes in developing a single modality [15]. The core purpose of this study is to suggest a relative analysis using previous research to identify a tweet's mood with percentage analysis.

Structure of the Paper: The rest of the paper is organised into the following sections: Primarily, we discussed the sentiment analysis process and evaluation measures for sentiment analysis used in past research. After that, a detailed comparison of some of the core techniques has been discussed. In the end, we concluded the paper with an informed viewpoint on the field of aspect-level SA, highlighting some of the most auspicious guidelines for forthcoming research.

2. BASICS OF SENTIMENT ANALYSIS

IThe section describes the key concept of the sentiment analysis process. That is further divided in sentiment and opinion definition and sentiment mining task. The detail of each section is as follows:

2.1 Sentiment and Opinion Definition:

Opinions expressed in textual reviews, as shown in Figure 1, provide information about the movie, whether it is nice or bad or average of their star scale rating. From this it has been observed that,

Different applications	Different Ratings
Movie review	
Product review	
Politics	
Public sentiments and social sites	

Fig.1. Review Example

if the movie is five stars, it expresses that movie is going to be good if three-star it expresses average review of the movie [15-17].

Opinions expressed in the form of textual reviews, share few common elements that correspond to the key components of user's opinion, named as the opinion target and the opinion polarity [18-20].

- Opinion has been expressed on the basis of a unit known as the opinion target. For example, the sentence "I find this MP4 player really useful" expresses a sentiment about the entity i.e., mp3 player. The target of the entity could be a person, a product, an organisation, or an event, among others [21].
- In its simplest form, the sentiment polarity is the degree of expressing a sentiment that can be negative or positive. The author shows a positive sentiment about the MP4 player in the earlier example. In contrast, the sentence "I don't recommend buying this TV" represents a negative sentiment about certain TV. Sentiment can also be neutral if the user does not express the polarity about the item he is talking about, as in the sentence "I bought this Cap 2 years ago", there is neither implicit nor explicit opinion about the Cap [22-25].

2.2 Sentiment Analysis Process

A starts from the application setting and then to the extraction of data from sources. The next step is to choose an appropriate sentiment analysis technique to mine this data for getting the final decision about any product or entity. [26-30]

The SA process is shown in Figure 2, which typically initiates from the pool of records, i.e. comments, reviews or it may be any opinion from different sources such as social media forums and blogs. But it should be kept in mind that the gathered information must be goal-oriented and pertinent to the objective of the sentiment systems. For this, one can extract data with keywords or queries [31]. Once relevant data is extracted, it is stored in some repository or database for the next step i.e. pre-processing. Pre-processing reduces the size of data by eliminating noisy and redundant data. Below subsections demonstrate the anatomy of SA.

3. CLASSIFICATION MODELS FOR SENTIMENT ANALYSIS

This section elaborates on some of the key classifiers that are widely used in the sentiment analysis process. The supposed classifiers have been implemented on a common dataset. The results of the obtained classifier have been discussed in the below sub-stations.

3.1 Methodology of study of Naïve Bayes Classifier

In the influence project, the researcher concluded

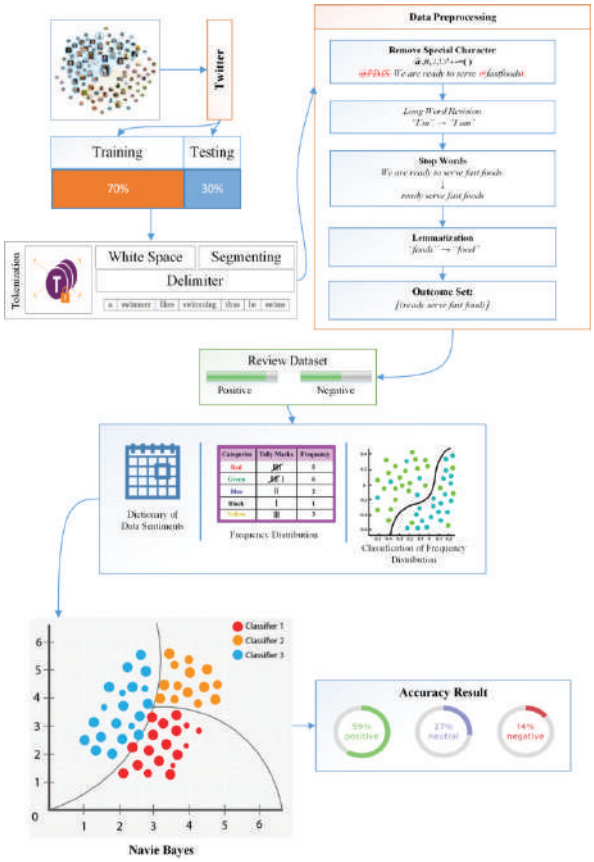

Fig. 2. Flow Diagram of Sentiment Analysis

that the Naive Bayes classifier provides better results based on the experiment results than K-NN [32]. It is based on the Bayes theorem of the prediction error. The classification method is allocated to the class C*=*arg maxP*(⁄$_d$) in a given document d where no position is played by P (d) in selecting c*. Including the class names, the classifier provides relative chances, which reflects the value of a decision [33-34]. Every tuple is defined by an n-dimensional attribute vector; taking into account a training set and the corresponding class labels, the classifier decides that the reference vector corresponds to the highest confidence prediction error. There are two separate ways to set up Naïve Bayes, the Multilayer perceptron model, and the Bernoulli model [35]. The documents are the groups in the multinomial model that are viewed as a different' language' in the calculation. BernoulliNB (Bernoulli Naïve Bayes) is appropriate for univariate values and is structured and operates with frequency counts for Operands functionality.

3.2 Result on the dataset

Since the reliability of the Naïve Bayes classifier is high in providing excellent performance for the dataset of Sentiments, it is known to be used in this study to know if this behaves the same on the Twitter data set selected. In empirical statistics, the Bayesian classification discovers its origin; its features are also mathematically demonstrable. The experiment is performed using two supervised algorithms on the film analysis dataset (NB and K-NN). The NB method outperforms K-NN, offering up to 80% precision. Table 1show the details of the dataset used.

Table 1: Dataset Statistics

Dataset	Positive	Negative	Neutral	Total
Training	600	600	600	1800
Testing	50	50	50	150

3.3 Lexicon Based Classifier

Another classifier lexicon-based classifier is used to generate opinions. For this purpose, lexicon-based classifier falls into two categories dictionary and corpus-based approaches. There are a number of methods in the dictionary which are generated through bootstrapping methodology that comprise a minimum set of basic opinion words and another dictionary WordNet or SentiWordNet. Different sustainable resources of dictionaries are built which are used as a semi-supervised technique with WordNet and generate a lexical resource that is assigned to WordNet to have the decision of data. Dictionary-based technique is used to find sentiments with domain and context orientation [44]. Domain corpus is used by corpus-based technique.

3.4 Methodology of study of Extra tree classifier

The Additional Trees algorithm operates by generating a large number of extremely randomised decision trees from the training sample [36-38]. Assumptions are developed on the basis of analysis by combining the estimation of the decision trees or by using a qualified majority in the classification phase.

- *Regression:* Forecasts are made via decision trees by averaging predictions.
- *Classification:* Forecasts from decision trees made by a qualified majority.

The Extra Trees algorithm fits every decision tree

on the entire training dataset, against bagging and arbitrary forests that build each tree structure from a validation set of the training sample. The Extra Trees algorithms will un-label the features from each point directly of a decision tree, such as a random forest. The Extra Forests method assigns a split point at normal, unlike a random forest, which uses a greedy algorithm to pick an optimal split point. Python machine learning library of scikit allows the implementation of extra trees for machine learning [39-41].

This model is also known as an extra randomised tree. Through SK-learn Count Vectorizer, Count Vectorizer () model made vectors of the frequency of words used in the dataset. We initialised the decision tree classifier using clf. First, we gave training sets to the model and then the model predicted the results on test sets. The extra tree algorithm worked by creating a decision tree from the training dataset. Predictions are made by regression and classification of the decision tree. The resultant accuracy is about 65%, according to this model [42].

3.5 Methodology of study of Support Vector Machine (SVM)

Support Vector Machine (SVM) is a machine learning algorithm for supervising that is used in classification and regression problems. In classification issues, however, it is often used. We visualised each piece of data in the SVM classifier as a location in n-dimensional space (where n shows the number of varieties you have), with each characteristic's value being the value of a certain coordinate [43-46]. Then, we performed by discovering the hyper-plane that distinguishes the two groups very well, as shown in Figure 3.

Help Vectors are essentially optimised control coordinates. The SVM classifier is a boundary that divides the two groups most effectively (hyper-plane/line).

This model worked on the same pattern of training and test set used in the last two models. SVM support vector machine. SVM used a technique for the transformation of the dataset and found optimal boundaries for output based on that transformation.

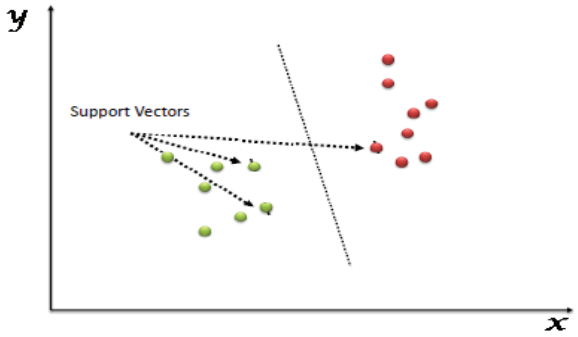

Fig. 3. Classification by using the SVM classifier

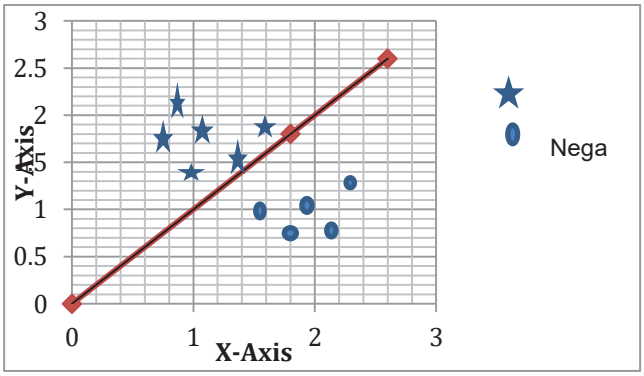

Fig. 4. Transformation of the dataset using optimal boundaries in SVM

Some complex data transformation is done and then the labelled dataset and output are defined [47]. The output in the form of the accuracy of sentiments used in a dataset in comparison with the labelled dataset counted as about 69.1% according to this algorithm used as shown in Figure 4.

3.6 Methodology of study of KNN classifier

K-nearest neighbours (KNN) is considered an easy-to-implement and simple supervised machine learning classifier, that can be used to address both classification and regression problems is the) algorithm. The KNN algorithm claims that in close vicinity, similar items happen. Similar objects, in other words, are close to each other. It is also managed. A linear classifier based on the closest groups. To the extent that needs to be categorised. The qualified majority class is given a test set based on the values of the closest K classes. However, according to their distances from the test point, weight is allocated to each of the k points to enhance this algorithm.

K- nearest Neighbor One of the simplest and supervised techniques in which first of all data is split into two parts train the dataset and test the dataset with a 70-30 ratio as mentioned in the above-supervised models. Some calculated functions are performed in python for the prediction of a dataset based on similarity measures. And finally, the result is generated. The majority vote always makes classification through this model to its neighbours [48-50]. For this model, two machine learning libraries are necessary to import; (1)- K-Neighbours Classifier for the implementation of K-nearest neighbours vote; and (2)- accuracy score from sklearn metrics for accuracy classification score [47]. Accuracy scored for sentiments of the dataset using KNN is measured as 62.8% as shown in Figure 5.

Different performance metrics computed are given in Figure 5. KNN-classifier has achieved an accuracy score of 62.8%, which shows that the KNN-classifiers have correctly classified 62.8% of the dataset. The precision value computed is 70%, indicating that KNN-classifiers have extracted 70% relevant instances from the group of retrieved instances. Similarly, Recall performance measure score was also depicted in Figure 5.

4. OPEN ENDED LIBRARIES FOR SENTIMENT ANALYSIS

Most of the SA process is normally implemented in Python, which is an interpreted, high-level, interactive, and object-oriented language. Python is developed to be highly comprehensible and has limited syntactical constructions than other programming languages. In this section, the core python libraries are discussed that are utilised in the standard SA process.

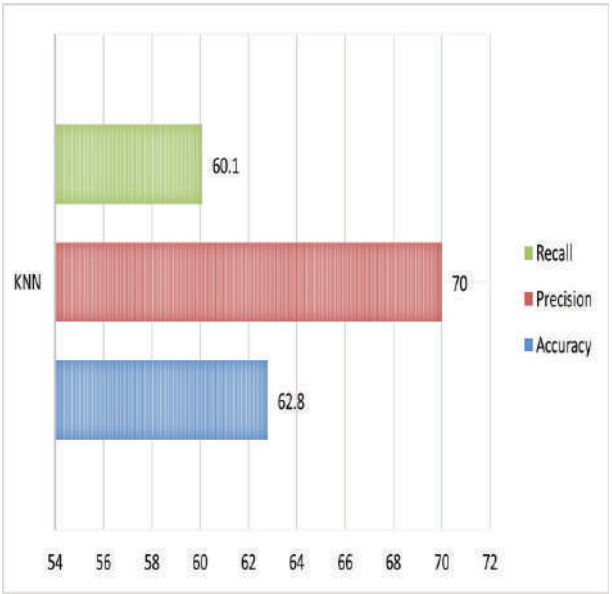

Fig. 5. Accuracy measured in comparison to the labeled dataset using KNN

4.1 NLTK

It is a python library that works with data in human language and offers various lexical tools such as WordNet and text mining libraries with an easy-to-use interface. These lexical tools are used for grouping, tokenisation, trailing, tagging, filtering, and semantic reasoning [43, 55].

4.2 Pandas

It is a python library that serves as a platform for data processing and is concerned with data structures. In Python, Pandas perform a full data analysis methodology without attempting to bend to a more database language such as R [55].

4.3 Sci-kit-learn

It is an easy and powerful data mining and data processing tool. The core of this is based on tokenisation, pre-processing, and segmentation [55].

4.4 Matplotlib

Python library of matplotlib is used that produces graphs, bar graphs, power spectra, data sets, etc. The matplotlib. pyplot module is used in SA process to plot the metrics [55-56].

4.5 Gensim

This library is used to remove semantic topics from files. Gensim is intended to process data from raw, unstructured text. Many algorithms are designed in Gensim, such as Word2Vec, where the semantic phrase structure is automatically discovered by analysing statistical patterns of excellent anti within a corpus of training documents. They are unsupervised by these algorithms. If these statistical trends have been established, any plain text document can be articulated succinctly in a new linguistic structure, asking for topical similarities to other documents [57].

4.6 Keras

Keras is a Python-written high-level neural network API capable of running on control of TensorFlow, CNTK, or Theano. With a focus on allowing quick experimentation, it was developed. It is crucial to do decent research to be willing to get from the idea to the outcome with the shortest amount of delay [58].

5. EXİSTİNG BENCHMARK METHODS FOR SENTİMENT ANALYSİS

With the improvement of web-based social organising (e.g. Twitter, Facebook, YouTube, etc.) on the Internet, all such decisions are dynamically utilising the substance available on social media to create a reasonable vital choice. Now a day, in case someone buys an item, he is no more restricted to surveying an individual's supposition on the internet. Similarly, for an organisation, it isn't compulsory to carry on studies, open supposition surveys, and centre groupings for knowing the view of humans as all such information is transparently available on the internet [26]. However, to perfectly analyse all such reviews, different SA-based and text mining techniques have been proposed, making it able for brands, products, services, politicians, societies, social sites, and facts influencing societies to conclude and abstract the subjective information. Broadly, it has been observed that sentiment analysis approaches revolve around keyword-based, variations based, and advanced approaches such as contextual semantic search

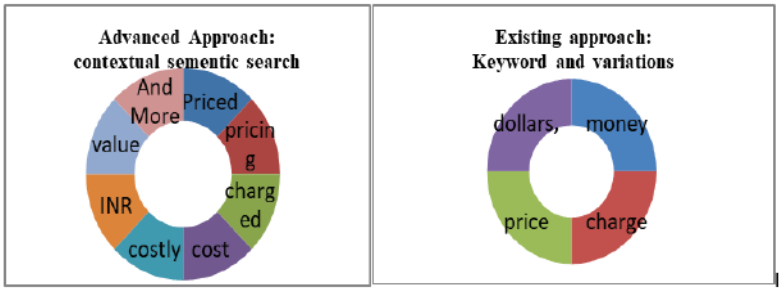

Fig. 6. Existing approaches Vs Contextual semantic search [45].

[45] as shown in Figure 6. This section presented the literature review on some of the core sentiment analysis approaches. This section also highlighted the strengths, major contributions, methodology and obtained results of the past approaches.

Hegde et al., [45] designed a system for extracting and analysing Tweets and their classification that recommend the outcome as positive or negative with the assistance of machine learning methods and algorithms. In the end, they check the performance of their system by using standard performance evaluation techniques. Their proposed system focused on the demonetisation of Tweets and they implement two classifiers i.e. Naïve Bayes and SVM that classify the Twitter dataset into positive and negative. The author of this work used an oversized dataset that showed better outcomes. They conclude that Naive Bayes performed satisfactorily, but failed to exceed expectations. Further, they also conclude that Logistic Regression performed similar to Support Vector Machines and took less time as compared to Naive Bayes which performed satisfactorily but failed to exceed expectations.

In another research study on the analysis of the Twitter data Alsaeedi & Khan [5], observed that Twitter turned into famous microblogs where customers may have voice notes about their opinions. The main theme of their work was to test the existing sentiment evaluation strategies on Twitter records. In the end, they designed a new framework to furnish the theoretical comparisons with the existing state-of-artwork tactics. Their experimental results concluded that their proposed framework outperformed the current frameworks by obtaining 92% precision in double characterisation and 87% in the course of a multi-elegance grouping. They used numerical strategies that were based on iterative scaling and quasi-Newton optimisation to generally hired to clear up the optimisation problem. Their model was based on Maximum entropy by following the equation (1) and (2) [5]:

$$p_{MaxEnt}\left(\frac{a}{b}\right) = \frac{exp[\sum_i a_i f_i(a,b)]}{\sum_a exp[\sum_i a_i f_i(a,b)]} \quad (1)$$

The method of computing for distinguishing likelihood through naïve Bayes technique [5]:

$$p(\frac{a}{b}) = [p(\frac{b}{a}) * p(a)]/p(b) \quad (2)$$

Textual content mining strategies and sentiment evaluation turned into represented via way of means of Hussein [46]. Their paper summarised the keys of sentiment demanding situations regarding the kind of evaluation structure. Their studies mentioned that sentiment demanding situations, the elements affecting them, and their importance. Moreover, in their work they applied the assets of noise labels as schooling data. But numerous demanding situations are dealing with the sentiment evaluation and assessment process. These demanding situations turned out to be boundaries in reading the correct which means of sentiments and detecting the right sentiment polarity. A facet of social media data like Twitter messages is also important [47]. It included rich, structured information about the individuals involved in the communication. Their work tried a hybrid of a bag of words with SVM which improved the accuracy. Their contribution achieved an accuracy of 68:36% with training at only around 9000 tweets and testing on 1100 tweets. However, they did not include the effect of the subsequent features on classification accuracy.

In another study on Twitter data analysis, a new method was suggested that plays with the class of tweet sentiment on Twitter by Sheela [48]. Their work reinforces its scalability and efficiency by introducing Hadoop Ecosystem, a widely-followed dispensed processing platform. Their technique was based on the following steps: Data Streaming, Pre-processing, Sentiment Polarity Analysis, and Visualization. They performed a comparison of various sentiment analysers and validated the results with the controlled classifiers environment. The author's contribution included adopting a hybrid approach that involved a sentiment analyser supported machine learning. Additional functionality that was added to the authors' work was to see the accuracy of existing analysers. The translation of the Urdu language was also a unique contribution to the present research which wasn't present in any previous work. In their work they have created an account on Tweet, API linked to his Twitter account to retrieve the tweets.

Text mining and the hybrid KNN algorithm and Naïve Bayes were discussed in [49] to locate the emotions of Indian humans on Twitter. They attempted to fetch the opinion, and facts to investigate and summarise the evaluations

expressed on routinely computers. They targeted the extraction of beneficial facts to approximate the Facebook user's sentiment polarity (whether or not it's far positive, impartial or negative). They define their dataset from the messages written with the aid of using users. Then, their approach mainly started with the extraction of tweets that further led to pre-processing of the extracted tweets. After which they introduce a distance function along with KNN as represented in Equations 3 and 4 [49].

$$\sqrt{\sum_i^n (ai - bi)^2} \quad (3)$$

Manhattan distance function:

$$\sum_i^n = |ai - bi| \quad (4)$$

Where, $\{(a_1,b_1),(a_2,b_2),(a_3,b_3),\ldots,(a_n,b_n)\}$ is training datasets. Furthermore, they implemented features like to find emotions, smileys; injections as they recently become a huge part of the internet.

The study of Avinash et al. [50] used different techniques to analyse Twitter using machine learning and lexicon-based approaches. Their research was distributed and was using sentiment analysis to determine the general public mood. The methodology used during their work was keywords-based for recognising feelings. In their work, they utilised Lexical affinity, Statistical method, Machine Learning Methods, and Sentiment Generation Prediction. In the end, they conclude that machine learning methods like SVM and Naive Bayes have the best accuracy and might be considered as the baseline learning method. Furthermore, they also conclude that lexicon-based methods were also effective. However, in some situations lexicon methods were simpler to implement than SVM and Naive Bayes.

The research of Gupta et al., [16] focused on finding sentiment for Twitter data due to its unstructured nature, limited size, slang, misspelling words, and abbreviations. Their research was based on the working of two machine learning algorithms K-Nearest Neighbors (KNN) and Support Vector Machines (SVM) in an exceedingly hybrid manner. The basic functionalities of their works are: Using the prediction probability of both the algorithms on each test tweet to assign the category having greater probability. From the comparative results, they conclude that KNN shows an improved accuracy and f-measure of tweet class prediction, but the number of features for the learning classifier was limited during this approach.

After the standard models, many advanced approaches to tackling emotions from textual data exist. LBT and ML are major components of opinion mining [24] [25]. A detailed review of LBT comprises two factors: a DBA (dictionary-based approach) and CBA (Corpus-based approach). In DBA justification of each collected term is taken manually. The major problem associated with DBA is handling domain orientation [31] [28] [30]. Whereas, CBA uses Statistical approaches along with counting frequencies in a bundle of documents. Sentiment analysis for NPL is also a very restricted domain [35]. However, advances in this domain considered this as an incentive domain of NPL.

6. SIMILARITY MEASURE FOR SENTIMENT ANALYSIS

There are numerous similarity measures for information extraction and classification that can be applied for sentiment analysis like the chi-square test [30]; Jacquard's coefficient [33] and information gain, etc., although, they are justifiable, they are purely statistical and suitable for numeric values. As far as the sentiment analysis process is concerned, similar measures are different as compared to numeric values. Following similarity measures are widely used in the sentiment analysis process to achieve remarkable accuracy.

- ***Recall:***

This measure calculates how sample tweets from all set of tweets that should have been anticipated as belonging to the classification were accurately guessed for a particular region. Their percentage in terms of positive cases that have been correctly reported is measured using the equation below [7], [30], and maybe abbreviated as a true positive rate (TP).

$$\text{Recall}=TP=D/(D+C) \quad (5)$$

- ***Precision:***

The precision metric allows measuring how several

tweets contributing to a certain group have been correctly predicted from all the texts that are accurately or improperly predicted. Precision (P) is used to measure the right expected positive cases, as determined using the equation [30]:

$$\text{Precision\_c}=d/(d+p) \quad (6)$$

Precision measure is used to denote the total number of true positives for an observed class against all the cases in a given class. The recall measure is the number of true positive values for a given class versus the total number of data points in the given class. F1 scores are the harmonic mean of recall and precision. The functions are denoted below:

$$\text{Precision}_c = \frac{tp_c}{tp_c+fp_c} \quad (7)$$

$$\text{Recall}_c = \frac{tp_c}{tp_c+fp_c} \quad (8)$$

- ***F1-score:***

The calculation of the weighting factor of accuracy and recall is the F1 score. The Prediction accuracy varies between 0 and 1 and when it is 1, the F1 score is acceptable, indicating that the model has low positive and false negatives [30].

$$F1-Score = 2\,X\,\frac{Precision * Recall}{Precision + Recall} \quad (9)$$

where c = {positive, negative, neutral}. For each class c, TPC is the count of true positive, FPC denotes the count of false positive, fnc shows the count of false negative, and tnc is used to count the true negative. The precision measure computes the scoring system label against the actual label. The recall measure computes the effectiveness of a scoring system label against the effectiveness of the actual label [15]. We evaluate the proposed classification performance based on the precision measure.

7. COMPARATIVE ANALYSIS OF THE EXISTING LITERATURE

The last section of this research work provides a detailed comparison of the past research models in terms of accuracy. Table 1 showed the final accuracy of the said model when they were deployed on the same dataset.

Table 2: Values for accurate measurements of algorithms

S.NO	Algorithm	Resultant Accuracy
1	Lexicon based	41.5%
2	Extra tree classifier	65%
3	SVM	69.1%
4	KNN	62.8%
5	Naïve based (proposed pipeline)	79%

In this research work, four different techniques, one unsupervised and three supervised, have been compared. Lexicon Based an unsupervised technique gave accuracy of 41.5%, Extra Tree classifier an Ensemble/supervised technique gave an accuracy of 70.5%, Decision Tree again a supervised technique gave the accuracy of 65.7% and last one SVM a supervised technique measured the accuracy of sentiments with the labeled dataset 69.1%. For the Extra tree classifier, the Decision Tree and SVM default sklearn configuration are used. This research also experimented on KNN-classifier, which returned the 62.8% accuracy. Whereas, the graphical representation in Figure 7 shows that the performance of naïve Bayes and ensemble is out of the mark. The total word count of the dataset is 369805; it scores an accuracy of 79%.

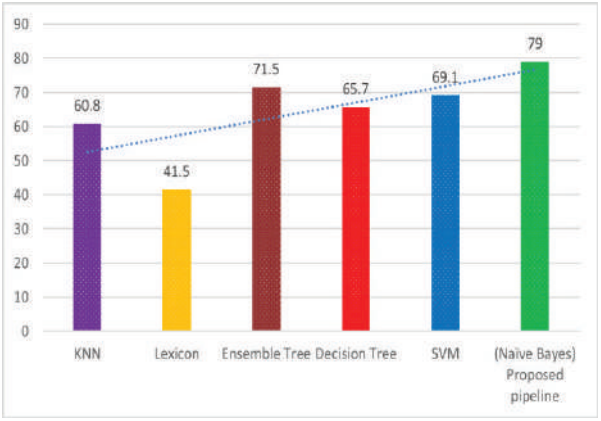

Fig. 7. Accuracy Results from different Classifiers

The accuracy score against the different state-of-the-art classifiers is presented in Figure 7. Among these classifiers, naïve Bayes classifier showed excellent accuracy score of 79%. In addition to this, the Ensemble approach also produced respectable result by giving 71.5% accuracy score. Similar

accuracy score of the SVM classifier is also notable.

8. CONCLUSION AND FUTURE WORK

This research work tries to attempt the anatomy of sentiment analysis process. Initially, in this work the complete process of SA has been elaborated. In the very next phase standard classifiers have been discussed. Brief discussion on some of the core research along with open ended libraries is also part of this work. Last but not the least, this work provides a detailed comparison in term of accuracy of the core classifiers when they have been implemented on the same datasets. The experimental results show that, within an appropriate experimental setting, the performance of ensemble and naive based approaches is better than existing state-of-the-art methods. In future, some of the other classifiers will be utilised and discussed to resolve sentiment analysis issues. A very crucial and indispensable future effort shall be to combine existing research with machine learning techniques for aspect based sentiment analysis.

9. CONFLICT OF INTEREST

Authors have no conflict of interest in publishing this article.

10. CONFLICT OF INTEREST

There is no conflict of interest among the authors.

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Research Article

Evaluation of Electric Field for a Dielectric Cylinder Placed in Fractional Space

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Abstract: The problem related to the dielectric cylinder placed in non-integer dimensional space (FD space) is thoroughly investigated in this paper. The FD space describes complex phenomena of physics and electromagnetism. We have solved Laplacian equation in FD space to obtain the solution of a dielectric cylinder in low frequency. The problem is solved by the method of separation of variables analytically. The classical solution of the problem can be easily recovered from the derived solution in non-integer dimensional space.

Keywords: FD-Space,--Laplacian-Equation,--Quantum-Field-Theory,--Ising-limit

1. INTRODUCTION

The concept of non-integer dimensional space (FD -space) has been considered a very useful in various areas of physics and electromagnetism and many researchers [1 – 16] have discussed and applied it previously. Wilson [3] has employed this idea in the quantum field theory. Further, it was suggested that the FD-space can be used as a parameter in the Ising limit in quantum field theory [6]. Stillinger [4] has provided an axiomatic basis of this concept for the formulation of Schrodinger wave mechanics and Gibbsian statistical mechanics in α -dimensional space. Svozil and Zeilinger [10] have presented operationalized definition of the of space–time which has provided the possibility of experimental determination of space–time dimension. It has also been stated that the non-integer dimension of space–time is slightly less than 4. Gauss law [11] has been formulated in α-dimensional fractional space. The solution of electrostatic problems [13 − 18] have also been investigated in the FD space considering $(2 < \alpha \leq 3)$. In the present work, we have extended the dielectric cylinder problem and solved it analytically in non-integer dimensional space. The main objective is to use the Laplacian equation to find electric potential and the field due to a dielectric cylinder in non-integer dimensional space. To retrieve the integer order, we may consider $\alpha = 3$. As a result, the original solution is recovered.

2. MATHEMATICAL MODEL

We have considered an infinitely long circular cylinder of radius 'a', which is made up of a material having a dielectric constant (ϵ/ϵ_0) and is placed in uniform electric field E0. The cylinder is oriented with its axis at the right angle to the applied primary field $E0r(\alpha - 2)\cos\theta$. We will find the potential and electric field in non-integer space $(2 < \alpha \leq 3)$ in the three regions. We will employ the cylindrical coordinates (r,θ) for the appropriate solutions.

Since the total charge enclosed within the region is zero, so we can use Poisson's equation:

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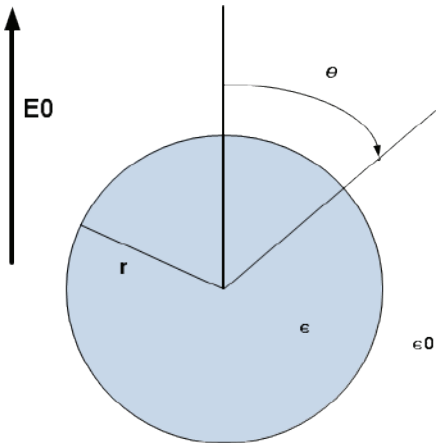

Fig.1: Dielectric Cylinder Placed in Fractional Space

Since the total charge enclosed within the region is zero, so we can use Poisson's equation:

$$\nabla^2\Phi(r,\theta) = 0 \quad (1)$$

This is also known as cylindrical wave equation and is expressed as follows,

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial\Psi}{\partial}\right) + \frac{1}{r^2}\frac{\partial^2\Psi}{\partial\phi^2} + \frac{\partial^2\Psi}{\partial z^2} + k^2\Phi = 0 \quad (2)$$

We will deal with this problem in electrostatic and magnetostatics, where $\omega = 0$ so that $k = 0$. As the translational symmetry of the cylinder is considered to be along z-axis, so 'Φ' is independent of 'z' and we need to consider the problem in the (r,θ)- plane only. Further, symmetry in this problem leads us to choose cylindrical coordinates in which Poisson's equation is expressed as follows,

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial\Phi}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2\Phi}{\partial\theta^2} = 0 \quad (3)$$

The separation of variable method solves the Eq. (3) and its possible solutions in the uniform electric field are $r\cos\theta$ and $r^{-1}\cos\theta$. The general solution for low frequency can be expressed as follows,

$$\Psi(r,\phi) = \sum_{l=0}^{\infty}\left(A_l r^l + B_l r^{-l}\right) P_l(\cos\theta \quad (4)$$

where, $P_1(\cos\theta) = \cos\theta$.

Eq.(3) can also be solved by separable method in non-integer space.

Let suppose,

$$\varphi(r,\theta) = R(r)\Theta(\theta) \quad (5)$$

$$\left[\frac{d^2}{d\theta^2} + (\alpha-2)\cot\theta\frac{d}{d\theta} + l(l+\alpha-2)\right]\Theta(\theta) = 0 \quad (6)$$

(6)

$$\left[\frac{d^2}{dr^2} + \frac{\alpha-2}{r}\frac{d}{dr} + \frac{l(l+\alpha-3)}{r^2}\right]R(r) = 0 \quad (7)$$

The solutions of the above angular differential equation (6) is obtained from [10] and expressed as Follows,

$$\Theta(\theta) = P_l^{\alpha/2-1}(\cos\theta) \quad (8)$$

(1)

Similarly, the solutions of the above radial differential equation (7) is obtained from [12] as r^l and $r^{-(l+\alpha-3)}$. Therefore, the general solution of scalar potential of dielectric cylinder in fraction space can be expressed as,

$$\Psi_e(r,\varphi) = \text{Xha}ir^l + \text{(2)}ir^{-(l+\alpha-3)}\text{i}P_{l\alpha/2-1}(\cos\theta)_{l=0} \quad (9)$$

For our convenience, we can limit the above form of the solution only within outside and inside of the cylindrical regions. For the outside region, we need to have the electric field at infinity, but we certainly don't want the field to diverge. It is that the logarithmic and r^l terms with $l > 1$ diverge as 'r' goes to infinity. Hence , these terms are unphysical and can not be considered. Therefore, we are interested only in the solution, for $l = 1$

$$P_1^{\alpha/2-1}(\cos\theta) = (\alpha-2)\cos\theta.$$

Because each region has the same symmetry with respect to the external field, so the expressions of potentials in each region are written as,

Outside the region:

$$\Psi(r,\phi) = -E_0 r(\alpha-2)\cos\phi + \frac{B}{r^{\alpha-2}}(\alpha-2)\cos\phi, \quad r > a \quad (10)$$

Here, for large values of 'r' the field is supposed to reduce to $-E_0 r(\alpha-2)\cos\varphi$, corresponding to the uniform field.

Inside the region:

$$\Psi^{i}(r,\varphi) = A\, r(\alpha-2)\cos\varphi \qquad r < a \quad (11)$$

For the determination of unknown coefficients 'A' and 'B' boundary conditions are applied. The fields must be continuous across the boundary at $r = a$, so using the boundary conditions we find the unknown coefficients A and B, which are expressed as follows.

$$A = \frac{-(\alpha-1)E_0}{\epsilon+(\alpha-2)} \quad (12)$$

$$B = E_0 a^{(\alpha-1)} \frac{\epsilon-1}{\epsilon+(\alpha-2)} \quad (13)$$

$$\Psi = -E_0 r(\alpha-2)\cos\phi + E_0\left(\frac{\epsilon-1}{\epsilon+(\alpha-2)}\right)\frac{a^{\alpha-1}}{r^{\alpha-1}}(\alpha-2)\cos\phi, \quad r > a \quad (14)$$

$$\Psi^{t}(r,\phi) = \frac{-(\alpha-1)E_0}{\epsilon+(\alpha-2)} r(\alpha-2)\cos\phi \quad r < a \quad (15)$$

The total electric field intensity is

$$E^{t} = E_0(\alpha-2)\left(1+a^{\alpha-1}\left(\frac{\epsilon-1}{\epsilon+(\alpha-2)}\right)\right)\left[\frac{(x^2-z^2)}{r^{\alpha+1}}u_x + \frac{(\alpha-1)xz}{r^{\alpha+1}}u_z\right] \quad (16)$$

The secondary electric field intensity is

$$E^{p} = E_0(\alpha-2)a^{\alpha-1}\left(\frac{\epsilon-1}{\epsilon+(\alpha-2)}\right)\left[\frac{(x^2-z^2)}{r^{\alpha+1}}u_x + \frac{(\alpha-1)xz}{r^{\alpha+1}}u_z\right] \quad (17)$$

3. CONCLUSION

In this paper the Laplace equation has been studied in α -dimensional fractional space. The potential and electric field of the dielectric cylinder is obtained in fractional space. The classical results are recovered from the investigated solution for $\alpha = 3$. Further, this solution can be applied for various materials. The host medium and core medium can be studied for multiple materials like meta-materials, plasma etc.

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5. CONFLICT OF INTEREST

There is no conflict of interest among the authors.

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Research Article

Mapping and Analyzing Coastal Morphological Changes due to Rising Sea Level: A Case Study of Karachi Port, Pakistan

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Abstract: Climate is noticeably changing because of several natural and anthropogenic causes i.e. deforestation, the use of fossil fuels, emission of CFCs, etc. consequently, it is disturbing the natural settings of the environment including glacial lake outburst floods, flash floods, cloud bursts, etc. Likewise, the sea level is also rising. The sea level is rising because of thermal expansion when water expands after getting warm in the ocean and the melting of glaciers. These changes in sea levels result in coastal morphological changes over time. In this context, Karachi is selected as a study area for the present research. Karachi Port and Port Muhammad Bin Qasim are the busiest port in Pakistan. For the study purpose, sea level data is obtained from National Oceanic and Atmospheric Administration (NOAA) Tides, Currents, and coastal morphological changes are digitized in Google Earth with the help of a historical timeline. The result shows that the sea level is rising at a rate of about 0.02 mm/year from 1916 to 2016 and 0.0032 mm/year from 1916 to 2016, 2020. Coastal morphological changes are identified in the Southern Karachi coast (accretion) and Eastern Karachi (erosion). NDWI also performed on satellite images for better assumption to detect a difference between 2000 and 2021 and the result shows the difference in the Southern Karachi coast and near Goth Manjar. These slow morphological changes are important to study for sustainable development in coastal areas

Keywords: Accretion, Coastal mapping, Erosion, Karachi port, Morphology, Rising Sea Level.

1. INTRODUCTION

Climate change is an emerging problem worldwide. Anthropogenic activities increased the concentration of greenhouse gases (GHGs) which caused many extreme weather events e.g., drought, floods, etc. worldwide in 2019 [1]. Due to climate changes (spatially-temporally), trends in sea level are very risky [2]. According to some observations, the rising sea level observed in the 20th century was due to global warming [3]. The global sea level is rising because glaciers are melting, ocean water expands when it warms [4], and on a local level because of tectonic plates, winds, tides, storms, sea surface temperature, currents, barometric pressure, and land subsidence [3]. According to Intergovernmental Panel on Climate Change (IPCC), sea levels will rise to 1 m in 2100 [4]. From 1993 to 2009, tide gauge data shows that the sea level had risen about 2.8 ± 0.8 mm year-^{1}, and satellite data shows about 3.2 ± 0.4 mm year-^{1} [5]. For example, Copenhagen capital city of Denmark, Calcutta city of India, Venice city of Italy, and Vancouver city of Canada are cities facing the problem: of rising sea levels [6]. It is estimated that rising sea levels may cause 20 million environmental refugees, 32% loss of rice production, and 8% loss of wheat production [7]. Countries at the edge of the Arabian Sea and the Bay of Bengal are at risk of rising sea levels [8]. Coasts are changing because the processes of oceanographic and geomorphic are taking place at a spatial-temporal (space and time) scale [9].

According to Intergovernmental Panel on Climate Change (IPCC) report in 2013, said that rising sea levels will cause many problems to the shoreline. Coastal morphology is a natural process that structure and restructure the coast by rising sea level, rainfall, and ocean waves in (spatial-temporal) space and time [10]. Coastal zones are

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at risk for coastal erosion as it affects public safety, and coastal infrastructure [11]. For example, in Ghana sea level had risen about 3.3 mm/year and caused coastal erosion at beaches in 2013 [1].

According to United Nations Environmental Programme (UNEP) in 1989 said that due to climate change Pakistan is also vulnerable to rising sea levels [12]. In Pakistan, the mean sea level (MSL) is slowly but gradually rising at a rate of about 1.1 mm/year and 10% of the population is living in coastal areas, 20% of the coast is developed and only 40% of industries are located near the coastal areas [13]. From 2007 to 2016, sea levels increased by about 3.6 mm/year and 2.1 mm/year for mean and extreme sea levels respectively at the Karachi coast [8], and coastal morphological processes e.g., erosion was recorded at about 2.43 ± 0.45 m/year at Karachi coast [14]. In the next 25 to 30 years, the sea level will rise to 15.62 centimeters, and the Karachi coastline experience erosion of about 2.43 ± 0.45 m/year [15]. The main purpose of the study is to find out how much the sea level is rising and how it affects the coast because in recent years, there is a few numbers of evidence studies regarding rising sea levels and extreme weather events [8]. For example, a research study found ground displacements, erosion, and sea level rise along the Karachi coast, of Pakistan [18]. One more study was conducted through remote sensing techniques for monitoring land subsidence in the coastal city of Pakistan. In the study sentinel using persistent Scatterers, In-SAR techniques were assessed [19]. This study aimed at finding rising sea levels from National Oceanic and Atmospheric Administration (NOAA) tides and current and morphological changes like temporal coastal erosion on the Karachi coast using Google earth imageries. The main aim of my study is to identify morphological changes in the rising sea level at Karachi Port. The objective of my study includes identifying sea level rise at Karachi port and detecting coastal morphological changes by rising.

2. MATHEMATICAL MODEL

2.1 Study Area

The study area of the present research is Karachi Port as shown in the Figure 1. Karachi is the capital of Sindh the province of Pakistan. It is one of the largest cities in Pakistan and a highly populated city [16]. It has a coastline of about 990 km [17] The Karachi coast is situated between Cape Monze and the Korangi creek and has many beautiful beaches i.e., Clifton beach, Paradise Point, Sea View beach, French beach, and Devil's point as shown in Figure 2. The purpose of choosing this area is because Pakistan is vulnerable to climate change and Pakistan has a coastline of about 990 km. Karachi is facing problems related to climate change i.e., rising sea levels.

Due to the rising sea level in Karachi, the coastline of Karachi faces some morphological changes. That is why we choose the Karachi coastline to detect morphological changes at Karachi Port to rising sea levels. Karachi coast has two ports, two fish harbours, nuclear power plant, a steel mill, and two industrial estates [14] Karachi port is an industrial and financial center of Pakistan. Pakistan and other countries mostly trade through this port. Now, Gwadar port through China Pakistan Economic Corridor (CPEC) will also play a role in developing better economic conditions for Pakistan.

2.2 Data and its Sources

Both types of data sources i.e., Primary and Secondary data sources are used. Coastal morphological changes were collected at the Karachi coast by a primary source. Coastal morphological changes are identified by digitizing the coast of the year December 1985, September 2001, December 2003, November 2010, and February 2021 at Karachi through Google earth (historical image) as shown in the Figure 4. The strategy for the study follows the following steps as shown in Figure. 3 below.

Sea level data is collected by secondary sources from National Oceanic and Atmospheric Administration (NOAA) Tides and Currents. Sea level data is collected from the year 1916 to 2016. Also collected the data for the first five months of 2020 for better assumptions from the Sea Level Station Monitoring Facility. On the other hand, for better assumptions collected the satellite images from a secondary source from the United States Geological Survey (USGS) department to determine coastal morphological changes through

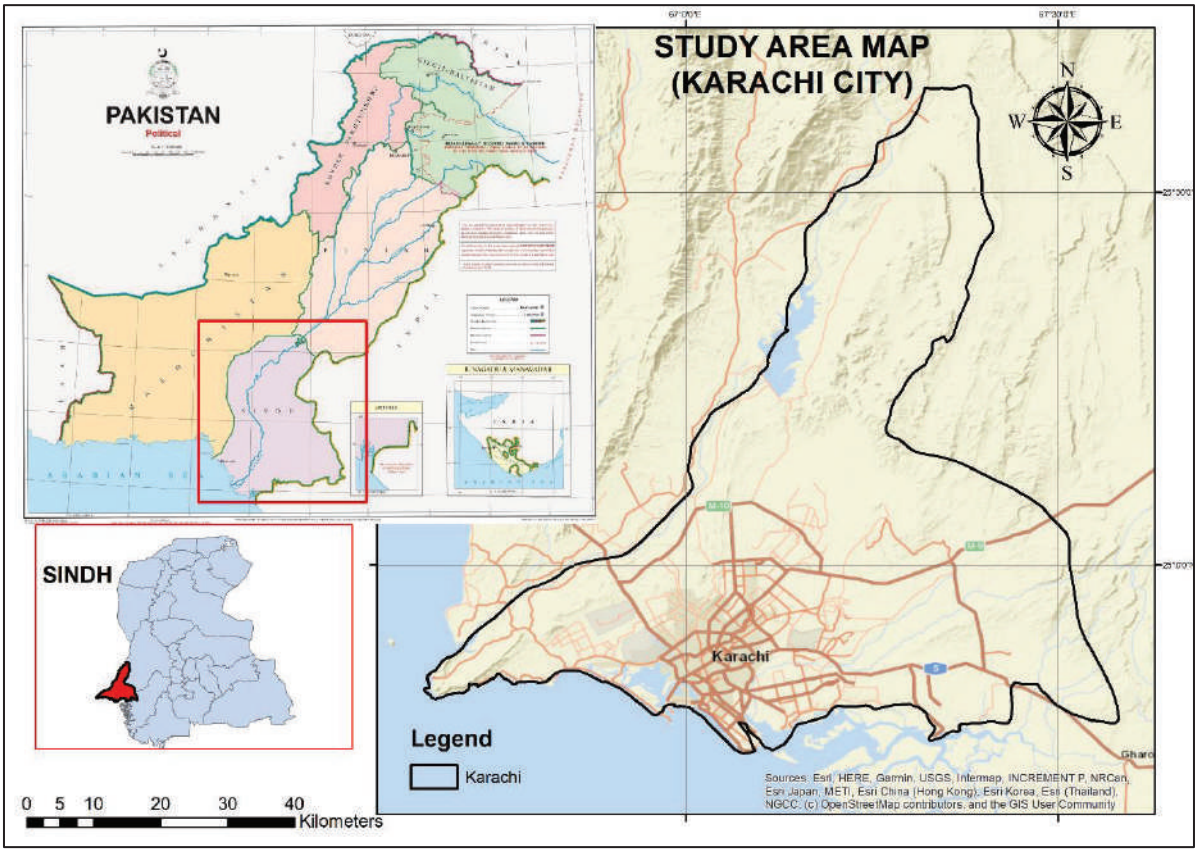

Fig. 1. Depicting the study area (Karachi), Pakistan

Fig. 2. Shows the coastline of Karachi (February 2021)

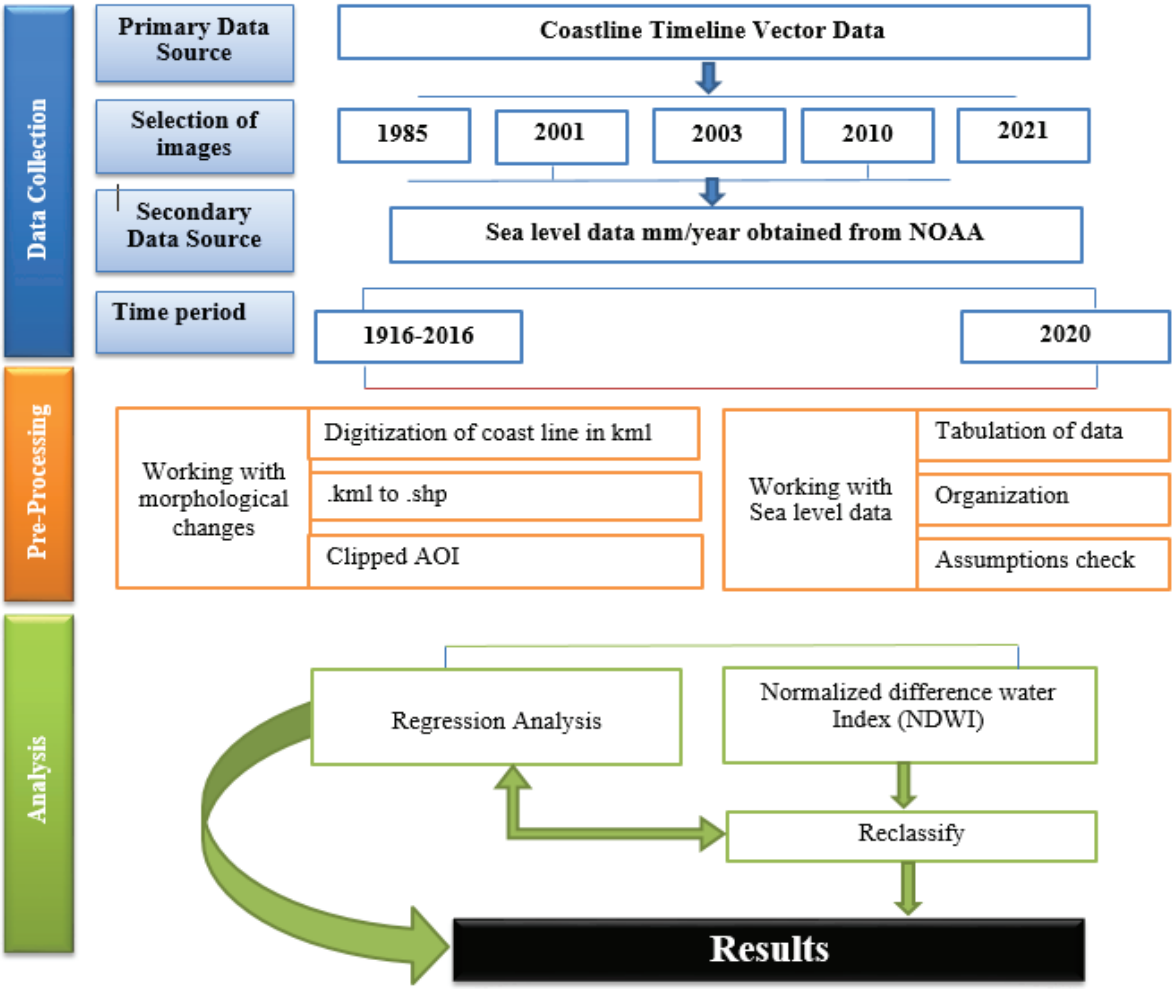

Fig. 3. Flowchart of Research Methodology

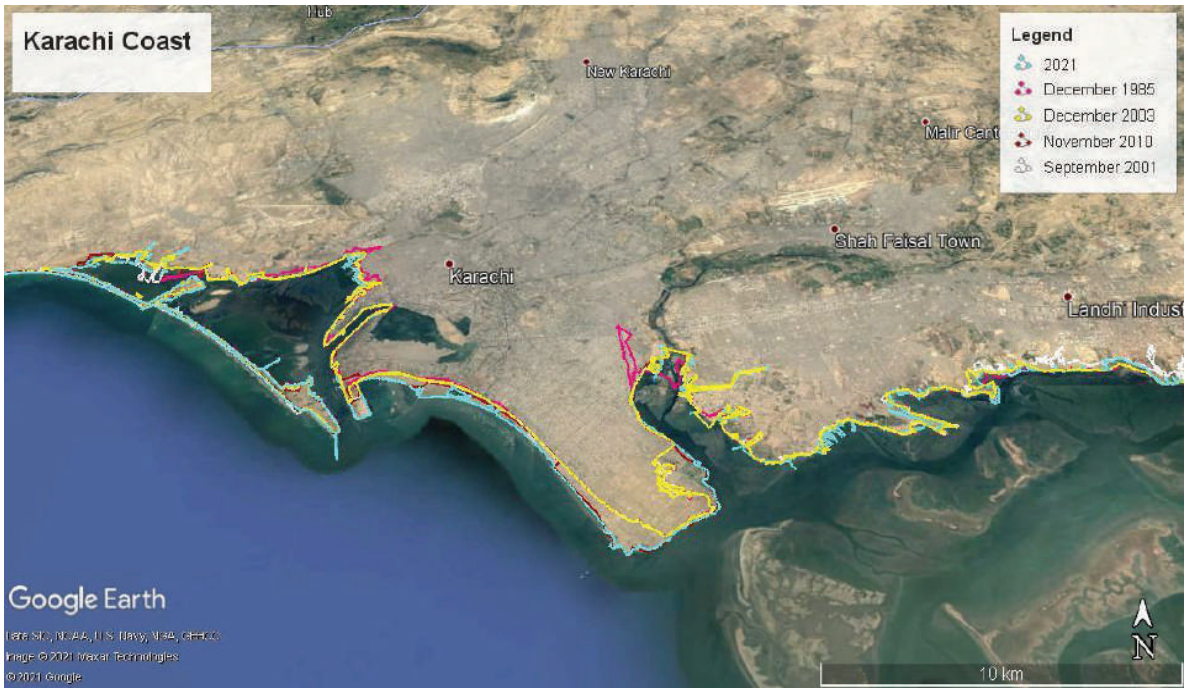

Fig. 4. Mapping morphological changes from 1985 to 2021 in Karachi Coast, Pakistan

Normalized Difference Water Index (NDWI). For this purpose, Landsat 8 Operational Land Imager and Thermal Infrared Sensor (0LI/TIRS) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) were used. Sea level data is tabulated and organized in excel. Coastal morphological changes are tabulated and organized in Arc GIS.

2.3 Data and Analysis

After tabulation and organization of sea level data. Calculated the averages of sea level data obtained from National Oceanic and Atmospheric Administration (NOAA) Tides and Currents from 1916 to 2016 and 1916 to 2016 and 2020 in excel. After the organization of coastal morphological changes of the year 1985, and 2001. 2003, 2010, and 2021 in Keyhole Markup Language (kml) format and inserted these kml files into Arc GIS and use the tool: detect feature change. On the other hand, satellite images want to identify the Normalized Difference Water Index (NDWI). Higher NDWI refers to sufficient moisture while lower NDWI refers to the stress of water.

$$\text{NDWI} = \frac{\text{Green}-\text{NIR (Near Infrared)}}{\text{Green}+\text{NIR (Near Infrared)}} \ldots\ldots\ldots \text{(E.1)}$$

Landsat 8, 2021 images.

$$\text{Landsat}_8 = \frac{\text{Band 3}-\text{Band 5}}{\text{Band 3}+\text{Band 5}} \ldots\ldots\ldots \text{(E.2)}$$

Landsat 7, 2000 images.

$$\text{Landsat}_7 = \frac{\text{Band 2}-\text{Band 4}}{\text{Band 2}+\text{Band 4}} \ldots\ldots\ldots \text{(E.3)}$$

Then used the tool: Map Algebra from the Arc toolbox. Hence, NDWI is performed. Then classified both NDWI images into threshold values. The threshold value of Landsat 8 (OLI/TIRS) and Landsat 7 (ETM+) is 0.05 and 0.15 respectively. Then Difference is applied to both images. It performs a change detection feature and creates a new layer with change in two categories (highest change and lowest change). Sea level data is presented in the form of scatter charts and also find the regression (trend line) of these charts. Coastal morphological changes are presented in form of maps in Arc GIS. Satellite images for NDWI are also presented in form maps in Arc GIS.

3. RESULTS AND DISCUSSION

The highest mean sea level was recorded at about 7.27 mm/year in 2015. The lowest mean sea level was recorded at 6.95 mm/year in 1986. The sea level increased at a rate of about 0.002 mm/year from 1916 to 2016 (Figure 5).

In the year 2020, the highest mean sea level was recorded at about 8.52 mm/year in May. The lowest mean sea level was recorded at about 8.05 mm/year in January. The sea level increased at a rate of about 0.0032 mm/year from 1916 to 2016 2020 as shown in the Figure 6.

Coastal morphological changes show both erosions due to rising sea levels and accretion due to the reclamation of land on the entire coastline.

Figure 7 shows that's the changes in 1985, 2001, 2003 and 2010. The result shows that the entire coastline indicates N, which means there are, changes on the entire coastline. D indicates those features that are completely eroded by water and most probably covered with water. It means the entire coastline has shown changes since December 1985. Mostly, coastal accretion changes are identified in South Karachi in DHA Phase 6 and Korangi Creek. Mostly, coastal erosion changes are identified in East Karachi in Muhammad Bin Qasim Port. West Karachi also shows a sign of erosion but not an at-risk level.

The result shows a difference in NDWI between satellite images of 2000 and 2021 (Figure 8). It shows areas with coastal morphological changes. It indicates high and low coastal morphological changes. The difference shows changes near Goth Manjar from 2000 to 2021. Changes also show in South Karachi i.e., Manora Island (expansion of water). It will help to assess the impact of rising sea levels on coastal morphology. This study will help to plan a development project in the future at Karachi's coastline.

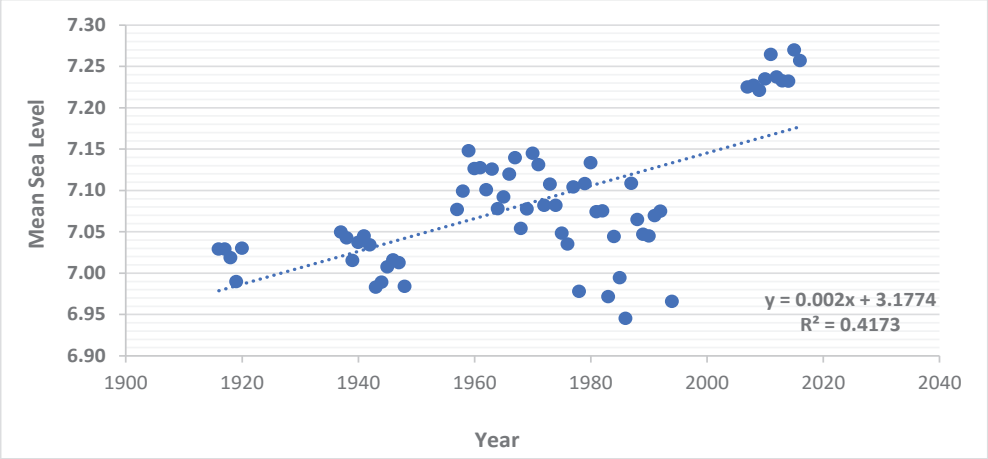

Fig. 5. Scatter chart with regression from 1916 to 2020.

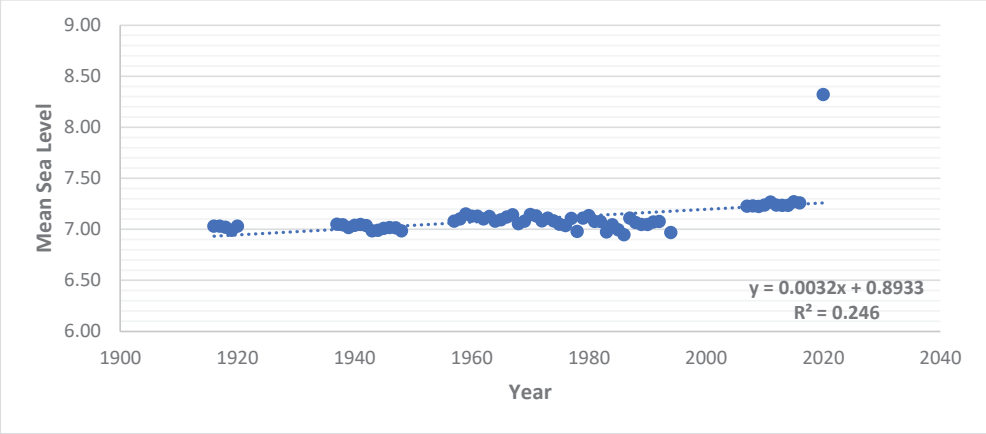

Fig. 6. Scatter chart with regression from 1916 to 2016 and 2020

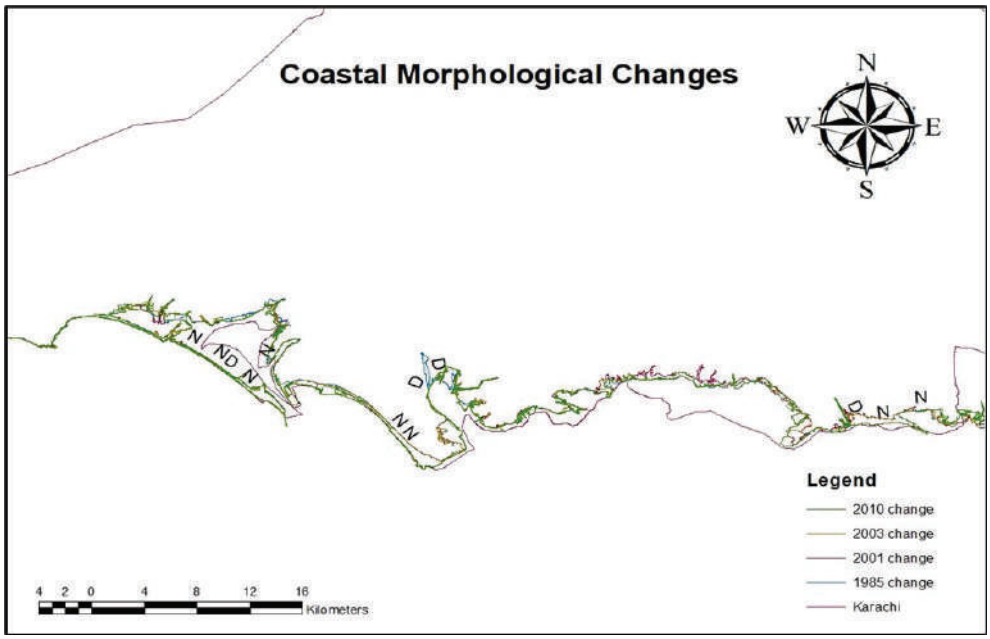

Fig. 7. Coastal morphological changes from 1985 to 2021

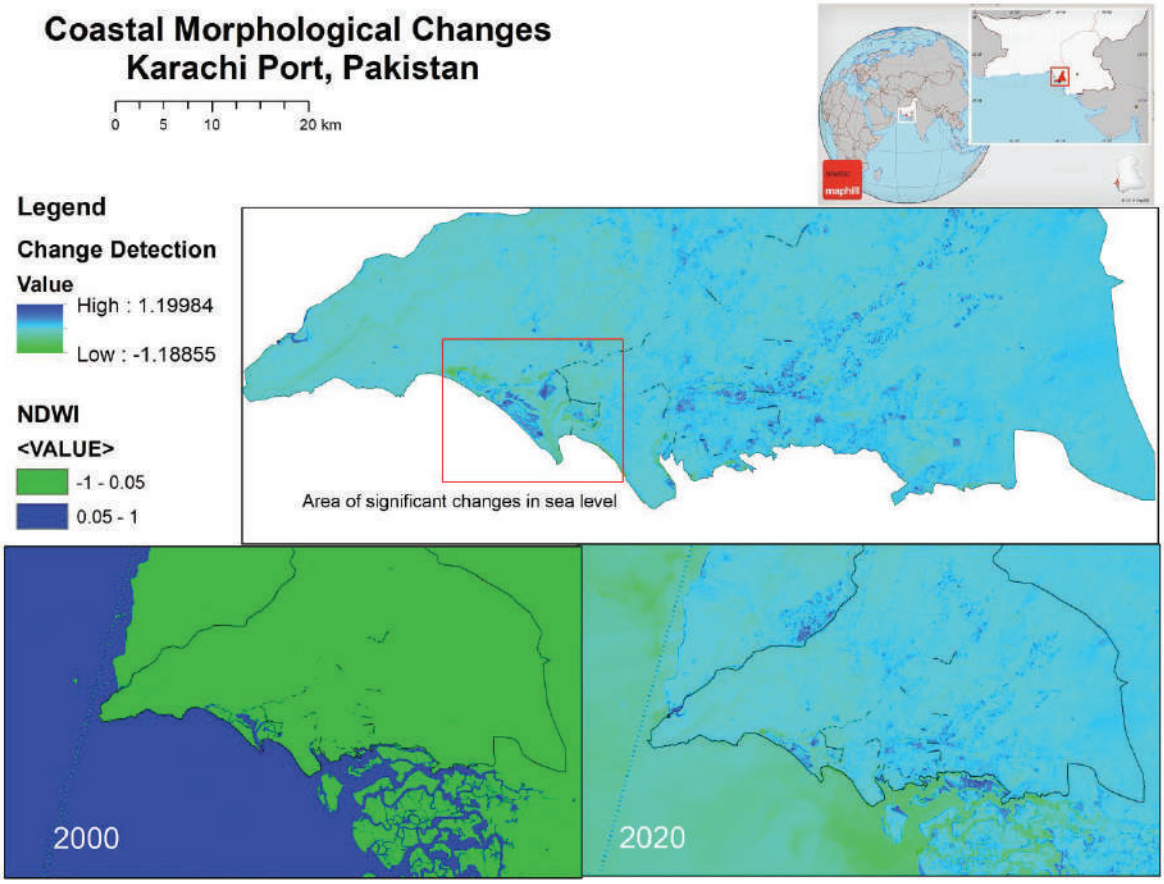

Fig. 8. Results of NDWI difference between 2000 and 2021

4. CONCLUSION

Climate is changing. It changes the trends of natural phenomena e.g., drought, floods, etc. Climate change also creates a problem for coastal communities by altering the patterns of rising sea levels. Copenhagen, Calcutta, Venice, and Vancouver are cities facing the rising sea level problem. Rim countries in the Arabian Sea are also at risk. Rising sea levels cause coastal morphological changes on the coast. It creates problems for those people who are residing in coastal areas or near coastal areas. Sandy beaches are also at risk due to rising sea levels and coastal erosion. Pakistan is also one of the rim countries of the Arabian Sea and the sea level is gradually increasing by about 1.1 mm/year. Karachi is also facing a rising sea level problem and it creates coastal morphological changes there like coastal erosion. I identified rising sea levels at the Karachi coast as about 0.002 mm/year from 1916 to 2016 and 0.0032 mm/year from 1916 to 2016 and 2020. Coastal erosion is mostly identified in East Karachi and West Karachi but not at-risk levels. Coastal accretion is identified in South Karachi (DHA Phase 6 and Korangi Creek). Some coastal morphological changes are also identified in South Karachi (Manora Island) and near Goth Manjar. To reduce the effect of rising sea levels, jetties, sea walls, and dolos should be planned. It is also necessary to promote ideas about coastal protection and provide awareness of climate change. So, that we protect our country from any disaster. Improve conditions for communities that are residing in coastal areas.

5. CONFLICT OF INTEREST

There is no conflict of interest among the authors.

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