POLLUTION MAPPING WITH REFERENCE TO TRANSMISSION SYSTEM IN EASTERN REGION

1. Introduction

Electricity, in the 21st century, plays a significant role in the socio-economic development of any country. With rapid advancement in the industrial sector and urbanization, per capita electrical energy consumption becomes a unit of measurement for the development of a country. Countries worldwide move for electrification all over its terrain. In order to have a reliable power supply, it is necessary to have a proper coordination between generation, transmission and distribution systems [1-3].

In general, the generating stations are located near the available energy resources. The transmission systems provide a bulk transportation path for the efficient transfer of electrical power from the generating station to the load centres with the larger geographical area. Distribution system distributes the electrical power from the load centre to the consumers with the smaller geographical area. In order to electrify load centres located at the larger distance and to transfer electrical power in an efficient manner, it becomes necessary to have a higher system voltage in the transmission network. Utilities all over the world are moving towards higher transmission voltages in their power lines and the system voltage up to 1200 kV has been adopted quite recently [4-5].

2. The Pollution Problem

Porcelain insulators play many vital roles in the power system such as bearing suspension and tension loads in the transmission line, as a supporting structure in substations, providing an optimal electrical insulation as indoor and outdoor insulators, provides the proper housing and grounding for live conductor by serving as bushings etc., Outdoor insulators, as the name suggests, are exposed to both man-made and natural pollution throughout their operation. Over a period of time, airborne particles in the atmosphere getting deposited on the insulator surface become one of the major hurdles in providing a reliable power supply [6-10]. The wind speed, electrical forces, and surface of the insulator determine the accumulation of soluble and non-soluble deposits on the insulator surface. When the

atmosphere is humid and foggy, the contaminant deposited on the insulator surface gets wet and form electrically conductive paths on the insulator surface. These events result in the flow of leakage current along the insulator surface, leading to the formation of dry bands and as a consequence of which pollution flashover may occur, especially in ceramic insulators [11-18]. The development of pollution flashover is shown in Figure 1 in three phases namely beginning, development and complete pollution flashover across a 33 kV insulator string under laboratorial conditions.

a) b) c)

Figure 1: The photographs showing (a) the inception, (b) growth and (c) a complete pollution flashover across a 33 kV insulator string. [19]

The design of external insulation is based on air gap performance of the rod plane gap for lightning and switching impulse voltages. It is to be noted that positive switching impulse performance of the rod plane gap is very critical. Once the performance characteristics of the rod plane gap have been obtained, the air gap for a given system voltage, will be decided. The performance of rod plane gap is non-linear and hence, the air gap requirements are also non-linear. The number of insulators which depends on the air gap, for a given system voltage, is also non-linear because of the above mentioned fact. Hence, creepage distance is also non-linear with respect to increase in system voltage. Therefore, the pollution performance of the insulators is very important in EHV and UHV transmission systems [20-28].

It is clear that the environment and system voltage on which the insulator operates collectively with the insulator itself will determine the pollutant accumulation on the surface of the insulator. Once the flash over event occurs, the system breaker on auto re-closure subsequently operates and repeats as long as the condition favoring flashover persists. Normally, after three trips the line trips off and the reason for the fault is investigated before the line is manually reclosed.

Tripping because of pollution flashover can't be nullified unless and until the wetting conditions get cleared, which threatens the reliability of electrical supply systems. The pollution trippings reported in the Indian transmission system (220kV and above) in recent times is listed in table 1. It is necessary to have sufficient knowledge of the pollution severity prevailing in the field and the behaviour of the insulator under polluted conditions. The selection of outdoor insulation should be made in such a way that the insulator is capable of withstanding the pollution severity.

Table 1: Pollution Trippings Recorded in the Indian Power System [26-28]

SI. No	Date & Time	Loss of Load (MW)	Trippings Recorded in the Transmission line (220 kV and above)	Affected Locations
1	27th January 2007 (08:12 hours)	3500	201	Punjab, Haryana, Chandigarh (Union Territory), Rajasthan, Himachal Pradesh, Uttar Pradesh, Uttarakhand, Delhi and Jammu & Kashmir
2	7th March 2008 (07-08 hours)	2000-6000	204	Delhi, Haryana, Uttar Pradesh, Punjab and Rajasthan
3	9th March 2008 (07-08 hours)	2000-5000	141	Delhi, Haryana, Uttar Pradesh, Punjab and Rajasthan
4	2nd January 2010 (03:01 hours)	7500	238	Punjab, North Haryana, Himachal Pradesh, Chandigarh (Union Territory) and Jammu & Kashmir
5	2nd January 2010	9000		Punjab, Haryana, Chandigarh (Union Territory), North-West

	(21:54 hours)			Delhi and Jammu & Kashmir

3. Background

From the knowledge of the earlier technical committee's and reports [1] [16], it is clear that the design and selection of insulation should be based on the pollution level prevailing on a particular site. With increase in wide occurrences of pollution flashover in power apparatus such as surge arrestors, bushings and cable terminations, it is obligatory to avail the information in connection with Site Pollution Severity (SPS).

In this connection, Central Power Research Institute (CPRI) proposed a consultancy project to Power Grid Corporation of India Limited (PGCIL) on October 2013 and a special meeting on Pollution Mapping of Eastern Region was held at Bangalore on 30th Oct 2013. In the 22nd meeting of Southern Regional Power Committee (SRPC) held during May 2013, PGCIL had presented an agenda on Pollution Mapping of Eastern Region and the same had been approved. A detailed deliberation regarding the furnished details of coordinates from utilities and a clear road map was spelt for interaction with the states. A contract agreement for "Pollution Mapping with reference to Transmission systems in Eastern Region" between Central Power Research Institute, Bangalore and PGCIL, Gurgaon was made on February 2014 with Contract No CC-CS/478-SRI/MISC-2481/3/G4/CA/4885 dated 26.02.2014. The contract agreement is enclosed as Annexure 1 for reference.

3.1 Geographical importance of Eastern Region of India

Eastern grid considered for the pollution mapping comprises of states namely Bihar, Jharkhand, Sikkim, West Bengal and Orissa. The Easternregion lies in the humid-subtropical zone, and experiences hot summers from March to June, the monsoon from July to October and mild winters from November to FebruaryThe interior states have a drier climate and slightly more extreme climate, especially during the winters and summers, but in general, the whole region receives heavy, sustained rainfall during the monsoon months. Snowfall often occurs in Sikkim and the extreme northern regions of West Bengal.

4 Eastern Region Pollution Mapping

4.1 Selection of Sites for Pollution Severity Measurement (SPS)

The selection of sites for pollution severity measurement has been made by mutual consent between CPRI Bangalore and PGCIL. The sites name and the number of locations in each site is mentioned in Table 2.

Table 2:Site Details

Sl. No.	State Name	Number of Sites
01	Bihar	120
02	Jharkhand	83
03	Odisha	159
04	Sikkim	18
05	West Bengal	111

4.2Pollution Measurements training provided by CPRI (for PGCIL and State Utilitiespersonnel)

With the logistic support of POWERGRID, training programon pollution measurementswasconducted by the officials of CPRI. The prospectus comprising of measurements of ESDD/NSDD and layer conductivity were provided to the attendees.The training manual includes

- Introduction to Pollution Phenomenon
- Methods of assessing pollution severity at site
- Design of external insulation from the point of view of pollution and pollution test methods
- Pollution monitoring in High voltage transmission system and remedial measures
- Pollution mapping carried out by different countries
- IEC 60815 (2008) recommendation for Pollution severity measurement

Practical training was imparted to utility personnel (PGCIL & State) for SPS measurements incorporatingESDD and layer conductivity methods. Pollution monitoring kits consisting of Digital conductivity meter, heating mantle, weighing balance, thermometer, beakers,

surgical gloves, filter paper, measuring jar and plastic mug were provided from CPRI end. A 2 kV AC source,layer conductivity measuring kitand plastic tent were also given to testing sites for leakage current measurements. The details of the study material distributed and photographs of training sessions are given on Annexure-2 and Annexure-3. The details of training program conducted at various locations and are shown in Table 3.

Table3: Details of training programs conducted

Sl.No	Locations of Eastern Region	Date
1	Durgapur	19-20 May 2014
2	Ranchi	21-22 May 2014
3	Jamshedpur	23-24 May 2014
4	Siluguri	26-27 May 2014
5	Subashgram	29-30 May 2014
6	Patna	19-20 May 2014
7	Muzafferpur	21-22 May 2014
8	Bhuvaneshwar	20-21 May 2014
9	Rurkela	23-24 May 2014
10	Jeypore	26-27 May 2014

4.3 Dummy insulator string installation

A dummy insulator string (comprising of 10 number of cap-and-pin insulators) were installed at each testing station. The insulator string was mounted at a height closer to the energized insulator in the identified tower. In addition to ESDD/NSDD measurements, layer conductivity measurements were carried out on few selected locations. It is to be noted that an additional insulator string was mounted along with the existing dummy insulator for layer conductivity measurements. Fig. 2 shows the dummy insulators installed at the identified testing tower.

Figure: 2 Photograph showing the dummy insulators installed at identified testing tower

4.4 Procedures Adopted

The selection of sites for the pollution measurements was brought out jointly on a mutual concern between CPRI and PGCIL.Grids of 25kmx25km were formed across the entire geographic area of Eastern Region of India and towers closer to the center, to the extent possible, were selected for installation of dummy insulator. Considering seasonal monsoon variations, periodical measurementswere carried out every four months for two years at each testing site.SPS measurements were carried out in reference with the recommendation set by IEC 60815.Figure3 gives pollution severity classification with respect to site pollution severity ESDD/NSDD. Table 4provides information about specific creepage distance required for corresponding pollution severity.

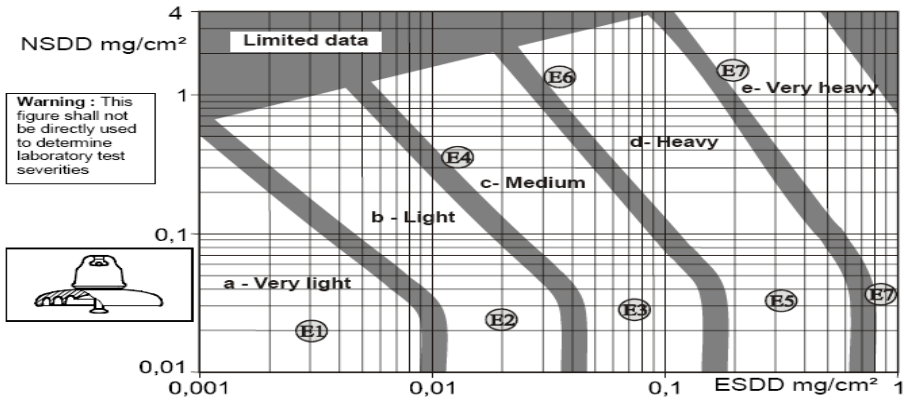

Figure2. Relation between ESDD/NSDD and SPS for the reference cap & pin insulator

Table4.Recommended specific creepage distance for various SPS level

Pollution level	Minimum Nominal Specific Creepage Distance (mm/kV)
Very Light	12
Light	16
Medium	20
High	25
Very High	31

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5 Results & Discussions

5.1 Results of Equivalent Salt Deposit Density measurements (ESDD)

For each identified site, the utilities are entailed to send six set of measurements. Each measurement possesses data's reflecting the conductivity of the pollutant (Top and Bottom surface of the insulator), NSDD and profile details of the dummy insulator.Additional details of the testing site such as volume & temperature of water, conductivity of demineralized water, nature of the pollutant and site GPSco-ordinates were provided by the utility personnel.

Based on the data set received, ESDD calculations were made for corresponding site.Maximum of average ESDD value among six measurements was considered as the ESDD prevailing in the given site [13].The corresponding NSDD pertaining to the maximum value of

ESDD were utilized to arrive at the SPS classification.

It is to be noted that, the pollution measurements were taken on the surface of the dummy insulators. There is also a possibility that the SPS class reported on-site may increase, owing to increased number of pollution sources in future. Considering the above observations, a pollution severity class one step higher than the reported site pollution severity is represented in the pollution mapping [14].

5.2 Site Pollution Severity (SPS) Classification for Bihar

Table 5 represents maximum SPS levels achieved on each testing stations out of six pollution measurements.Figure 3 represents the percentile variation of SPS measurements (measured& recommended SPS to be considered).

Note: The severity class for the sites in which ESDD/NSDD measurements have not been received is represented as No Results (NR)

Table5.Site Pollution Severity (SPS) Classification for Bihar

Sl.No	Location No	*UID*	*State*	*Latitude*	*Longitude*	*Name of the transmission line*	Maximum Average ESDD (Considering design & Energization factor)	SPS Classification (considering Design & energization factor)
1	101	BP001	BIHAR	27.2665	84.0178	132kV Ramnagar - Valmikinagar trans line	0.241837357	H
2	40	BP002	Bihar	27.1185	24.439	132kv narkatiyaganjsugar mill TR.LINE	0.318650255	H
3	206	BP003	Bihar	26.982	84.427	132 kvBettiah-Ramnagar trans line	0.344438818	H
4	106	BP004	Bihar	84.807094	26.933872	132kv bettiah-raxaul line	0.122678933	M
5	204	BP005	Bihar	26.757	84.54	123 KV Gopalganj-Bettiah trans line	0.375156058	H
6	70	BP006	Bihar	26.626	84.885	132kv Motihari-Sugauli line	0.121738249	M
7	12	BP007	Bihar	26.6476	85.1729	132kv Dhaka-Sitamarhi line	0.117693908	M

8	90	BP011	Bihar	26.478	84.68	123 KV Gopalganj-Bettiah trans line	0.337953258	H
9	195	BP012	Bihar	26.491	84.992	132kv MTPS-Motihari line	0.119004888	M
10	72	BP014	Bihar	26.5381	85.2976	132kv Dhaka-Sitamarhi line	0.120841597	M
11	165	BP030	Bihar	25.761	85.26	220KV MUZ-HJP D/C Transmission line	0.288461645	H
12	91	BP037	Bihar	25.5416	87.55211	132 KV Purnea - Katihar Single circuit Transmission Line	0.036149651	**L**
13	89	BP038	Bihar	25.54525	87.54962	132 KV Purnea - Katihar Single circuit Transmission Line	0.036546609	**L**
14	8	BP042	Bihar	25.249	87.247	132 KV NTPC KAHALGAON-KAHALGAON	0.031555977	**L**
15	133	BP045	Bihar	83.785771	25.043674	132 KV Sasaram-Kudara (KMS-1)	0.072638417	M
16	96	BP046	Bihar	85.2299	24,795,486	132 KV S/C Bodhgaya-Wazirganj	0.019465016	**L**
17	363	BP047	Bihar	25.1289	85.5337	400KV BIHARSHARIF-TTPS	0.127782121	M
18	71	BP048	Bihar	25.064605	86.0948042	132 KV JAMUI-SHEKHPURA	0.088413753	M
19	110	BP049	Bihar	84.0036	24.6958	132 KV Dehri-Banjari	0.068978503	M
20	149	BP050	Bihar	84.499	24.749	132 KV Chandauti-Sonenagar (L-30/31)	0.082606196	M
21	105	BP051	Bihar	85.203613184035 52	24.62762 14264963	132 KV D/C Bodhgaya-Paharpur Rly.	0.036890626	**L**
22	290	BP052	Bihar	24.6018	85.6151	400KV BIHARSHARIF-TTPS	0.092222021	M
23	43	BPBP007	Bihar	26.6434	85.0103	132kv Motihari-Dhaka line	0.106742282	M
24	306	BPBP01	Bihar	26.44758	84.472222	220 KV MTPS-GPJ	0.048779789	M

		0		3		Transmission line		
25	204	BPBP012	Bihar	26.371233	84.798888 3	220 KV MTPS-GPJ Transmission line	0.14802099	M
26	166	BPBP030	Bihar	25.758	85.261	220KV MUZ-HJP D/C Transmission line	0.328571271	H
27	22/7	BPBP031	Bihar	87.310905	25.755181 6	220KV PGCIL-Madhepura line	0.040628878	**L**
28	28	BPBP043	Bihar	25.2537	87.3092	132 KV NTPC KAHALGAON-LALMATIA	0.038643329	**L**
29	203	BPBPBP012	Bihar	26.370612	84.773723 3	220 KV MTPS-Gopalganj trans line	0.150280239	M
30	167	BPBPBP030	Bihar	25.756	85.263	220KV MUZ-HJP D/C Transmission line	0.287261251	H
31	216	BPER118	Bihar	85.1734	25.7031	132 KV SHEETALPUR - HAJIPUR T/L	0.122007229	M
32	133	BPER131	Bihar	83.785771	25.043674	132 KV Sasaram-Kudara (KMS-1)	0.02161556	**L**
33	8	BPER142	Bihar	25.226379	86.753434	132 KV Sabour - Sultanganj ckt-1	0.031546398	**L**
34	88	BPER145	Bihar	84.0331	24.7541	132 KV Dehri-Banjari	0.02161556	**L**
35	149	BPER147	Bihar	84.503023	24.81607	132 KV Chandauti-Sonenagar (L-30/31)	0.02161556	**L**
36	5	BTPS	Bihar	25.4035	86.0318	132KV BTPS-Khagaria	NR	NR
37	243	BTPS	Bihar	25.4661	86.6646	BTPS-Purnia	NR	NR
38	75A/1	ER101	Bihar	26°04'40.4" or 26.0778	84°58'49.8" or 84.9805	± 800 KV HVDC Saharsa-Gopalganj T/L	0.094896998	M
39	71/5	ER102	Bihar	26°03'08.7" or 26.0524	85°04'03.4" or 85.0676	± 800 KV HVDC Saharsa-Gopalganj T/L	0.091822022	M
40	348	ER103	Bihar	26° 03.914' or 26.06523	85° 22.101' or 85.36835	400 kV Biharsharif-Muzaffarpur TL	0.095544491	M

41	51/1	ER107	Bihar	25° 56' 45.6" or 25.946	85° 27' 29.7" or 85.45825	± 800 KV HVDC Saharsa-Gopalganj T/L	0.183545206	H
42	37/0	ER108	Bihar	25° 53' 55.6" or 25.8987	85° 37' 51.4" ro 85.63094	± 800 KV HVDC Saharsa-Gopalganj T/L	0.064415971	M
43	18-Mar	ER109	Bihar	25° 55' 0.7" or 25.9168	85° 56' 58.2" or 85.9495	± 800 KV HVDC Saharsa-Gopalganj T/L	0.072626622	M
44	151	ER119	Bihar	25 33.795' or 25.56325	85 42.404' or 85.70673	400 kV Biharsharif-Muzaffarpur TL	0.07420467	M
45	624	ER125	Bihar	25º-25'.215" or 25.42025	85º-23'.222" or 85.3870	400 KV Kah-Patna Line 1&2	0.029526988	**L**
46	547	ER126	Bihar	25º-21'.799" or 25.3633	85º-39'.419" or 85.65698	400 KV Kahalgaon-Patna 1&2	0.022310527	**L**
47	40	ER127	Bihar	25º-21'.9" or 25.365	85º-46'.719" or 85.77865	400 KV D/C LILO of Patna-Kahalgaon at Barh (Barh-Patna) CKT-1&2	0.019967678	**L**
48	393	ER140	Bihar	25º-08'.6" or 25.14333	86º-06'.913" or 86.115216	400 KV Kahalgaon-Patna 1&2	0.017238848	**L**
49	149	NA	Bihar	84.503023	24.81607	132 KV Chandauti-Sonenagar (L-30/31)	0.02161556	**L**
50	37	NA	Bihar	25.7792	84.7713	132KV CHAPRA-SHEETALPUR	NR	NR
51	44	NA	Bihar	25.4661	86.0011	132KV BEGUSARAI-SAMASTIPUR	NR	NR
52	206	NA	Bihar	26.982	84.427	132KV BETTIAH-RAMNAGAR	NR	NR
53	106	NA	Bihar	26.9338	84.807	132KV BETTIAH-	NR	NR

						RAXAUL		
54	105	NA	Bihar	24.6276	85.20361	132KV BODHGAYA-PAHARPUR	NR	NR
55	96	NA	Bihar	NA	NA	132KV BODHGAYA-WAZIRGANJ-NAWADA	NR	NR
56	158	NA	Bihar	26.2332	86.0264	132KV DARBHANGA-PANDAUL	NR	NR
57	221	NA	Bihar	26.098	85.9389	DARBHANGA-PHULPARAS	NR	NR
58	78	NA	Bihar	26.246	86.2925	DARBHANGA-PHULPARAS	NR	NR
59	133	NA	Bihar	25.0436	83.7857	132KV DEHRI-KARAMNASA CKT-1	NR	NR
60	12	NA	Bihar	26.6476	85.1729	132KV DHAKA-SITAMARHI	NR	NR
61	72	NA	Bihar	26.5381	85.2976	132KV DHAKA-SITAMARHI	NR	NR
62	118	NA	Bihar	26.0219	84.4966	132KV EKMA-SIWAN	NR	NR
63	265	NA	Bihar	26.250576	87.263454	132KV FORBISGANJ-KISHANGANJ	NR	NR
64	204	NA	Bihar	26.757	84.54	132KV GOPALGANJ-BETTIAH	NR	NR
65	91	NA	Bihar	26.479	84.679	132KV GOPALGANJ-BETTIAH	NR	NR
66	216	NA	Bihar	25.702	85.1763	132KV HAJIPUR-CHAPRA	NR	NR
67	8	NA	Bihar	24.9002	86.233344	132KV JAMUI-LAKHISARAI	NR	NR
68	71	NA	Bihar	25.0646	86.0948	132KV JAMUI-SHEKHPURA	NR	NR
69	5	NA	Bihar	26.000844	86.748417	132KV MADHEPURA-SUPAUL	NR	NR
70	150	NA	Bihar	26.1237	84.80068	132KV MASRAKH-SIWAN	NR	NR
71	43	NA	Bihar	26.6434	85.0103	132KV MOTIHARI-DHAKA-SITAMARHI	NR	NR

72	70	NA	Bihar	26.626	84.885	132KV MOTIHARI-SUGAULI	NR	NR
73	195	NA	Bihar	26.491	84.992	132KV MTPS-MOTIHARI	NR	NR
74	8	NA	Bihar	25.246	87.247	132KV NTPC-KAHELGAON	NR	NR
75	48	NA	Bihar	25.2172	87.353	132KV NTPC-LALMATIA	NR	NR
76	42	NA	Bihar	26.2903	86.57	132KV PHULPARAS-SUPAUL	NR	NR
77	132	NA	Bihar	26.039904	87.334506	132KV PURNEA-FORBISGANJ	NR	NR
78	91	NA	Bihar	NA	NA	132KV PURNEA-KATIHAR	NR	NR
79	89	NA	Bihar	NA	NA	132KV PURNEA KATIHAR	NR	NR
80	95	NA	Bihar	NA	NA	132KV PURNEA-KATIHAR)	NR	NR
81	101	NA	Bihar	27.2665	84.0178	132kv ramnagarvalmikinagar TR.LINE	0.12446305	M
82	40	NA	Bihar	27.1185	84.439	132KV RAMNAGAR-NARKATIYAGANJ	NR	NR
83	7	NA	Bihar	NA	NA	132KV SABOUR-SULTANGANJ	NR	NR
84	56	NA	Bihar	25.9985	85.8067	132KV SAMASTIPUR-DARBHANGA	NR	NR
85	145	NA	Bihar	26.494	85.502	132KV SITAMARHI-SKMCH	NR	NR
86	147	NA	Bihar	26.5007	85.5031	132KV SITAMARHI-SKMCH	NR	NR
87	149	NA	Bihar	24.816007	84.53023	132KV SONENAGAR-RAFIGANJ	NR	NR
88	133	NA	Bihar	26.251437	86.7324	132KV SUPAUL-KATAIYA	NR	NR
89	53	NA	Bihar	NA	NA	132KV SUPAUL-SAHARSA	NR	NR

90	380	NA	Bihar	NA	NA	220KV BEGUSARAI-BIHARSHARIF	NR	NR
91	61	NA	Bihar	25.9323	86.9836	220KV MADHEPURA-PURNEA	NR	NR
92	380	NA	Bihar	25.5016	86.0002	220kv MTPS-Begusharai	NR	NR
93	306	NA	Bihar	NA	NA	220KV MTPS-GOPALGANJ	NR	NR
94	132	NA	Bihar	26.039904	87.334506	220kv Purnea-Farbishganj	NR	NR
95	6	NA	Bihar	26.09215	87.91458	220kv Purnea-Kishanganj	NR	NR
96	22	NA	Bihar	25.7512	87.2873	220kv Purnia-Madhepura	NR	NR
97	363	NA	Bihar	25.1289	85.5337	400KV BIHARSHARIF-TTPS	NR	NR
98	290	NA	Bihar	24.6018	85.6151	400KV BIHARSHARIF-TTPS	NR	NR
99	149	NA	Bihar	NA	NA	Saharsha-UDAKISHENGANJ	NR	NR
100	53		Bihar	25°07'40.3"	87°09'49.1"	400 KV Khg - Barh T/L	0.04243671	**L**
101	133	BP17	Bihar	26.251141	86.7323743	132 KV KATAIYA - SUPAUL TRANS LINE	0.419121119	H
102	86	BP23	Bihar	85.85588	26.0827	132KV DARBHANGA - SAMASTIPUR TR. LINE	0.38707277	H
103	130	BP26	Bihar	26.258833	86.7367846	132 KV KATAIYA - SUPAUL TRANS LINE	0.429833662	H
104	72	BP008	BIHAR	26.5381	85.2976	132kv Dhaka-Sitamarhi line	0.104915004	M
105	147	BP009	BIHAR	85.503158	26.5006638	132kV Muzaffarpur-Sitamarhi line	0.104646052	M
106	306	BP010	BIHAR	26.447583	84.472222	220 kV MTPS-GPJ transmission line	0.104641472	M
107	145	BP015	BIHAR	85.501959	26.4939136	132kV Muzaffarpur-Sitamarhi line	0.104633271	M

108	42	BP016	BIHAR	26.2991	86.5644	132kv phulparas-supoul T/L	0.104629648	M
109	133	BP017	BIHAR	26.251141	86.7323743	132 KV KATAIYA - SUPAUL TRANS LINE	0.419121119	H
110	130	BP018	Bihar	26.25883	86.73678	132 KV KATAIYA - SUPAUL TRANS LINE	0.032859565	**L**
111	118	BP020	BIHAR	26.02	84.49	132KV SiwanEkma transmission line	0.104626342	M
112	86	BP023	BIHAR	85.85588	26.0827	132KV DARBHANGA - SAMASTIPUR TR. LINE	0.38707277	H
113	158	BP024	BIHAR	26.2332	86.0264	132KV DARBHANGA - PANDAUL TR. LINE	0.106859195	M
114	78	BP025	BIHAR	26.24	86.2955	132kv phulparas-darbhanga T/L	0.106667414	M
115	130	BP026	BIHAR	26.258833	86.7367846	132 KV KATAIYA - SUPAUL TRANS LINE	0.429833662	H
116	132	BP028	BIHAR	26.039972	87.3347559	132 kvPurneaForbesganj S/C Line	0.207710522	H
117	2	BP029	BIHAR	25.78	84.77	132 kV ekmachhapra line	0.110468304	M
118	241	BP034	Bihar	25.4709	86.6616	132kv BTPS Purnea DC T/Line	0.097031888	M
119	7	BP041	BIHAR	25.227176	86.749654	132 KV Sabour - Sultanganj ckt-1	0.031692601	**L**
120	28	BP043	BIHAR	25.2537	87.3092	132 KV NTPC KAHALGAON-LALMATIA	0.052697524	M

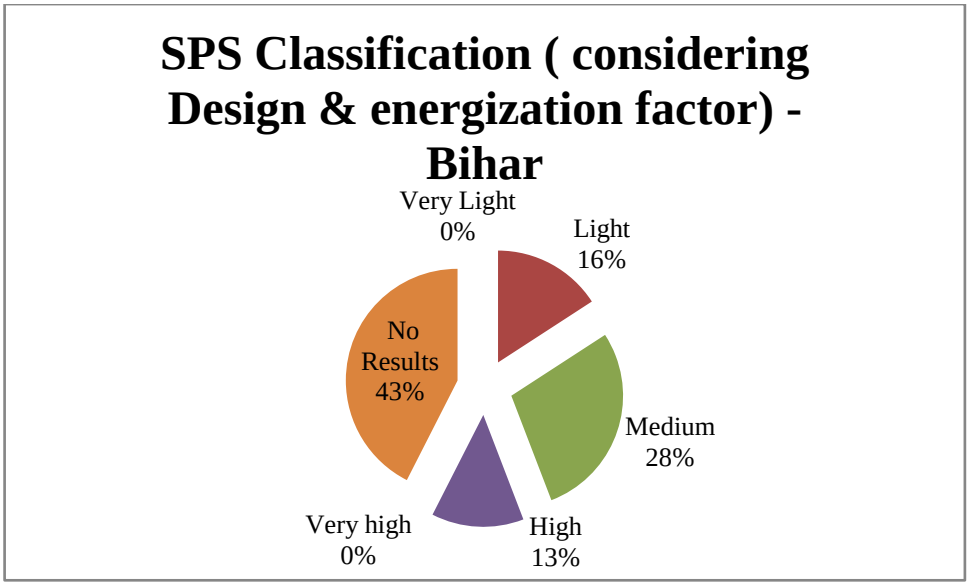

Fig. 3 Percentile Variation of Recommended SPS Class (for Design & Selection of Insulation) - Bihar

5.3 Site Pollution Severity (SPS) Classification for Jharkhand

Table 6 represents maximum SPS levels achieved on each testing stations out of six pollution measurements. Figure 4 represents the percentile variation of SPS measurements (measured & recommended SPS to be considered).

Note: The severity class for the sites in which ESDD/NSDD measurements have not been received is represented as No Results (NR).

Table6. Site Pollution Severity Classification for Jharkhand

Sl.No	**Location No**	***UID***	***State***	***Latitude***	***Longitude***	***Name of the transmission line***	**Maximum Average ESDD (Considering design & Energization) factor**	**SPS Classification (considering Design & energization factor)**
1	98	ER117	Jharkhand	25º-30'.229" 25.503816	84º-50'.559" or 84.84265	400 KV Patna-Balia CKT1&2	0.150290949	M
2	17(T)	ER170/JUS11	Jharkhand	23° 45 '15.3"	85° 45' 23.9"	TTPS-Biharsharif 400kv	NR	NR
3	116	ER175/JUS20	Jharkhand	23 37' 42.14"	85 18'48.51"	132KV Hatia PTPS	0.033193098	**L**
4	75	ER176	Jharkhand	23° 42' 45.3"	85° 30' 50.7"	TTPS-PTPS 400kv	0.199675613	H
5	264	ER177	Jharkhand	23.55445	86.05368	400KV Maithan -Gaya D/C LINE	0.023787021	**L**
6	264	ER177	Jharkhand	23.55445	86.05368	400KV Maithan -Gaya D/C LINE	0.029733776	**L**
7	166	ER178	Jharkhand	23.52332	86.25174	400KV Maithan -Gaya D/C LINE	0.017238848	**L**
8	166	ER178	Jharkhand	23.52332	86.25174	400KV Maithan -Gaya D/C LINE	0.02154856	**L**
9	975	ER179	Jharkhand	23.2928	84.9942	400KV RANCHI-Sipat D/C LINE	0.047190544	M
10	975	ER179	Jharkhand	23.2928	84.9942	400KV RANCHI-Sipat D/C LINE	0.00758475	VL
11	1036	ER180	Jharkhand	23.30206667	85.1945	400KV RANCHI-Sipat D/C LINE	0.01982189	**L**
12	1036	ER180	Jharkhand	23.30206667	85.1945	400KV RANCHI-Sipat D/C LINE	0.01902185	**L**
13	11	ER181	Jharkhand	23.2747667	85.40535	400KV RANCHI-Rourkela D/C LINE	0.078394888	M
14	11	ER181	Jharkhand	23.27476	85.40535	400KV RANCHI-	0.007592151	VL

				67		Rourkela D/C LINE		
15	468	ER182	Jharkhand	23°22.256' or 23.37093	85°36.024' or 85.6004	400KV RANCHI-Maithan D/C LINE	0.089790919	M
16	468	ER182	Jharkhand	23°22.256' or 23.37093	85°36.024' or 85.6004	400KV RANCHI-Maithan D/C LINE	0.089790919	M
17	830	ER184	Jharkhand	23.03038333	84.6007	400KV RANCHI-Sipat D/C LINE	0.098618433	M
18	192	ER184	Jharkhand	23 02' 11.94"	84 33' 50.77"	132KV S/C Kamdara-Gumla	0.029169342	**L**
19	830	ER184	Jharkhand	23.03038333	84.6007	400KV RANCHI-Sipat D/C LINE	0.081740033	M
20	914	ER185	Jharkhand	23.185	84.80455	400KV RANCHI-Sipat D/C LINE	0.106915831	M
21	914	ER185	Jharkhand	23.185	84.80455	400KV RANCHI-Sipat D/C LINE	0.031534019	**L**
22	81	ER186	Jharkhand	23.11418333	85.2787667	400KV RANCHI-Rourkela D/C LINE	0.187863687	H
23	81	ER186	Jharkhand	23.11418333	85.2787667	400KV RANCHI-Rourkela D/C LINE	0.187863687	H
24	1	ER187	Jharkhand	22 54' 32.32"	84 55' 46.98"	132KV S/C Kamdara-Gumla	0.057762363	M
25	235	ER189	Jharkhand	22°30.752' or 22.5125	085°20.971' or 85.34951	400 kvjamshedpur-Rourkela 1 Line	0.145842016	M
26	136	ER190	Jharkhand	22°40.357' or 22.672616	085°38.746' or 85.64643	400 kvjamshedpur-Rourkela-I Line	0.040384997	**L**
27	64	ER193	Jharkhand	22°39.749' or	086°24.185' or	400 KV JAMSHEDPUR-	0.044370569	**L**

				22.6624	86.403083	BARIPADA LINE		
28	198	ER194	Jharkhand	22°32'24.7'' or 22.54019	086°31'09.6" or 86.5193	400 KV JAMSHEDPUR-BARIPADA LINE	0.145842016	M
29	336	ER195	Jharkhand	22°21.532' or 22.3588	085°09.022' or 85.15087	400 kvjamshedpur-Rourkela II Line	0.031782414	**L**
30	257	ER196	Jharkhand	22°23'25.0'' or 22.3902	086°38'28.1" or 86.64113	400 KV JAMSHEDPUR-BARIPADA LINE	0.047190544	M
31	384	ER198	Jharkhand	23^{o}21.443' or 23.35721	85^{o}52.022' or 85.867033	400KV RANCHI-Maithan D/C LINE	0.044333351	**L**
32	384	ER198	Jharkhand	23^{o}21.443' or 23.35721	85^{o}52.022' or 85.867033	400KV RANCHI-Maithan D/C LINE	0.044333351	**L**
33	240	ER199	Jharkhand	23.30912	86.18839	400KV RANCHI-Maithan D/C LINE	0.153411751	M
34	336	ER2034	Jharkhand	23,20,363	86,26,520	400 kv s/c Durgapur - JamshedpurLine	0.22572645	H
35	336	ER2034	Jharkhand	23,20,363	86,26,520	400 kv s/c Durgapur - JamshedpurLine	NR	NR
36	1	JUS01	Jharkhand	24.496537	86.661061	132 kV Sultanganj-DeogharTr line	0.336901352	H
37	362	JUS04	Jharkhand	24.2259206	83.597754	132 KV SONENAGAR-PIPRI LINE	3.57100357	VH
38	251	JUS05	Jharkhand	24.227612	83.891527	132 KV SONENAGAR-PIPRI LINE	1.024200685	VH
39	149	JUS06	Jharkhand	24.01841	84.203419	132 KV	0.994053151	VH

				4		LATEHAR-DALTONGANG LINE		
40	84	JUS09	Jharkhand	23.889944	84.320775	132 KV LATEHAR-DALTONGANG LINE	1.164662948	VH
41	66	JUS10	Jharkhand	23 39' 05.13"	84 43'44.64"	220KV D/C LOHARDAGA-LATEHAR	6.797812145	VH
42	5	JUS12	Jharkhand	23 28' 56.49"	84 42'48.20"	220KV D/C LOHARDAGA-LATEHAR	7.487301804	VH
43	1	JUS16	Jharkhand	22.908944	84.929717	132KV S/C Kamdara-Gumla	0.173287089	M
44	9	JUS18	Jharkhand	22.887110	86.0594387	220 Kv S/C RCP-Chandil Line	41.52128415	VH
45	1	JUS19	Jharkhand	22 40' 34.68"	84 32' 51.71"	132KV Line Bay no.-01 (132/33KV GSS Simdega)	9.406447861	VH
46	179	JUS22	Jharkhand	22.442475	85.744536	220 KV S/C RCP -JODA	1.581033804	VH
47	115	JUS23	Jharkhand	22.395811	85.8051	132 KV S/C Kendposi - Rajkharsawan	1.795105007	VH
48	355	JUS25	Jharkhand	22.041314	85.411294	220 KV S/C RCP -JODA	1.797019794	VH
49	298	JUS26	Jharkhand	22.060094	85.474775	132 KV S/C Kendposi - Joda	1.997780689	VH
50	71	JUS27	Jharkhand	22.191814	85.522572	132 KV S/C Kendposi - Noamundi	2.388330639	VH
51	59	JUSJUS17	Jharkhand	22.765282 9	85.9598621	132 KvAdityapur-	0.409126375	H

						RKSN Line		
52	6	JUSJUS18	Jharkhand	22.829109	86.062538	220 Kv RCP-JODA Line	1.99607584	VH
53	24	JUSJUSJUS18	Jharkhand	22.8496295	86.1095468	132 KvAdityapur-Chandil Line	0.599432649	H
54	192	JUSNL4	Jharkhand	23 02' 11.94"	84 33' 50.77"	132KV S/C Kamdara-Gumla	0.029169342	**L**
55	353	MRB353	Jharkhand	23.44806667	85.81685	400KV RANCHI-Maithan (RB) D/C LINE	0.045441755	M
56	486	MRB486	Jharkhand	23.40425	85.4734	400KV RANCHI-Maithan (RB) D/C LINE	0.09799361	M
57	86	NA	Jharkhand	23.57052	86.3949	400KV Maithan -Gaya D/C LINE	0.024526977	**L**
58	445	NA	Jharkhand	23.52291	86.52055	400KV Maithan-Kahalgaon D/C LINE	0.023813713	**L**
59	29	NA	Jharkhand	23.44466	86.5339	400KV RANCHI-Maithan D/C LINE	0.026016943	**L**
60	158	NA	Jharkhand	23.37237	86.2366	400KV RANCHI-Maithan (RB) D/C LINE	0.191764689	H
61	87	NA	Jharkhand	23.42135	86.34314	400KV RANCHI-Maithan (RB) D/C LINE	0.047291966	M
62	3	NA	Jharkhand	23.48778	86.45324	400KV RANCHI-Maithan (RB) D/C LINE	0.135179423	M
63	182	NA	Jharkhand	23.35203	86.19567	400KV RANCHI-Maithan (RB) D/C LINE	0.045203041	M
64	141	NA	Jharkhand	22°	86°	400 kV	0.098618433	M

				39.743´	24.185´	Jamshedpur - Baripada Line		
65	64	NA	Jharkhand	22° 50.138´ / 22.83563	86° 04.552´ / 86.07586	400 kV Jamshedpur - Rurkrla Line	0.01982189	**L**
66	203	RKL203	Jharkhand	22.79302778	85.0921944	400KV RANCHI-Rourkela D/C LINE	0.025147356	**L**
67	535	RM535	Jharkhand	23°20.892'	85°25.194'	400KV RANCHI-Maithan D/C LINE	0.0632479	M
68	763	SPT763	Jharkhand	22.93108333	84.4040833	400KV RANCHI-Sipat D/C LINE	0.01902185	**L**
69	11		Jharkhand	23.2747667	85.40535	400KV RANCHI-Rourkela D/C LINE	0.08688496	M
70	17 (T)	JUS11	Jharkhand	23.754283	85.756603	TTPS-Biharsharif 400kv	101.2907234	VH
71	147	JUS14	Jharkhand	23.18	85.58	132 kV Chandil-Hatia& 220 kV Chandil - PGCIL Line	0.45195864	H
72	316	JUS15	Jharkhand	22.97	86.05	132 kV Chandil-Hatia& 220 kV Chandil - PGCIL Line	0.259914148	H
73	26	JUS17	Jharkhand	22.753081	85.882819	132 KV S/C RKSN - Chandil	0.193992687	H
74	116	JUS20	Jharkhand	22.628372	85.313475	132KV D/C HATIA-PTPS	0.232854174	H
75	10	JUS21	Jharkhand	22.5164403	86.4965035	132 kV (D/C) DVM - Musabani Line	0.605350803	H
76	38	JUS24	Jharkhand	23.4862301	85.5367137	132 kV S/C Golmuri - Jadugoda Line	0.087975957	M

77	192	JUSPG28	Jharkhand	23 02'11.94 "	84 33' 50.77"	132KV S/C Kamdara-Gumla	0.069145472	M
78	1	JUSPG29	Jharkhand	22 54'32.32 "	84 55' 46.98"	132KV S/C Kamdara-Gumla	0.08335464	M
79	38	JUSPG30	Jharkhand	23.4862301	85.5367137	132kV s/C Golmuri-Jadugada Line	0.827600131	VH
80	116	JUSPG31	Jharkhand	23.628444	85.3134	132KV D/C HATIA-PTPS	0.075146292	M
81	1	JUS02	Jharkhand	24.33094	87.21342	132 kV Dumka-PakurTr line	0.028672012	L
82	86	JUS03	Jharkhand	24.366	87.43	132 kV Dumka-PakurTr line	0.024140528	L
83	84	JUS09	Jharkhand	23.889944	84.320775	132 KV LATEHAR-DALTONGANG LINE	0.031607953	**L**

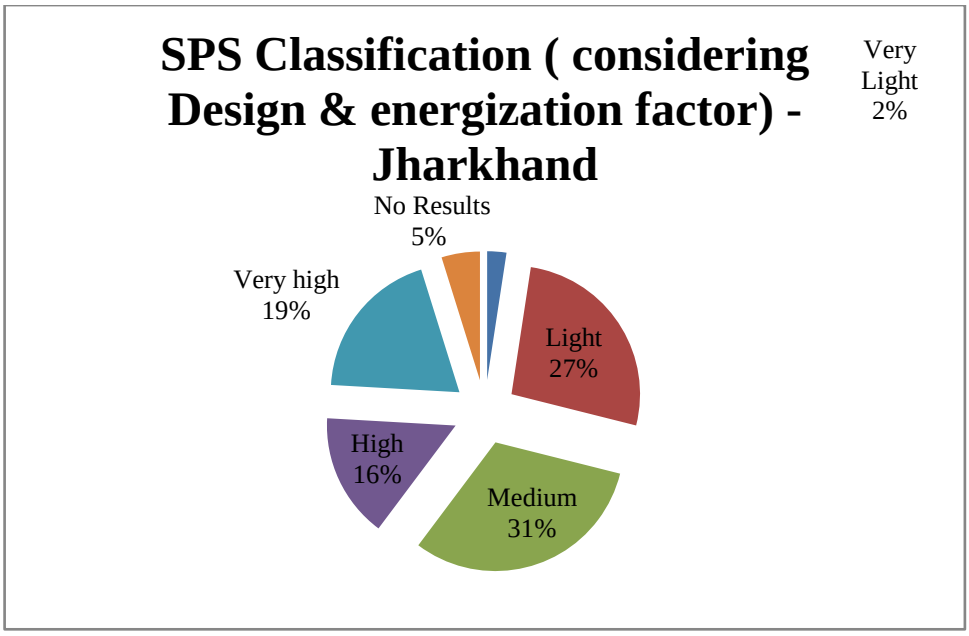

Fig. 4 Percentile Variation of SPS Classification (considering Design & energization factor) - Jharkhand

5.4 Site Pollution Severity (SPS) Classification for Odisha

Table 7 represents maximum SPS levels achieved on each testing stations out of six pollution measurements. Figure 5 represents the percentile variation of SPS measurements (measured & recommended SPS to be considered).

Note: The severity class for the sites in which ESDD/NSDD measurements havenot been received is represented as No Results (NR).

Table 7. Site Pollution Severity (SPS) Classification for Odisha

Sl. No	Location No	*UID*	*State*	*Name of the transmission line*	Maximum Average ESDD	Recommended SPS Class for Design & Selection of Insulation
1	107	ERO011	Odisha	400 KV Talcher-Rourkela D/CTransmission Line	0.04535006	M
2	931	ERO012	Odisha	400 KV RENGALI-INDRAVATI S/C Transmission Line	0.0142278	**L**
3	1021	ERO013	Odisha	400 KV RENGALI-INDRAVATI S/C Transmission Line	0.01458105	**L**
4	1078	ERO014	Odisha	400 KV RENGALI-INDRAVATI S/C Transmission Line	0.06037548	M
5	464	ERO016	Odisha	400 KV Angul-Bolangir S/C Transmission Line	0.01725023	**L**
6	371	ERO017	Odisha	400 KV Angul-Bolangir S/C Transmission Line	0.04289799	**L**
7	810	ERO028	Odisha	400 KV S/C Bolangir – Jeypore Transmission Line	0.08973182	M
8	478	ERO029	Odisha	400 KV S/C Indravati – Rengali Transmission Line	0.10329444	M
9	948	ERO032	Odisha	400 KV S/C Bolangir – Jeypore Transmission Line	0.13112794	M
10	377	ERO033	Odisha	400 KV S/C Indravati – Rengali Transmission Line	0.30786193	H
11	260	ERO035	Odisha	400 KV S/C Indravati – Rengali Transmission Line	0.21874025	H
12	1131(A+6)	ERO038	Odisha	400 KV Jeypore - Bolangir S/C Line	0.27673087	H
13	175	ERO039	Odisha	400 KV S/C Indravati – Jeypore Transmission Line	14.7557903	VH
14	1187 (A+0)	ERO041	Odisha	400 KV JeyporeBolangir S/C Line	0.16926408	M
15	37 (A+3)	ERO043	Odisha	400 KV Jeypore - Indravati S/C Line	0.28393566	H
16	4	OD001	Odisha	132/33 KVGrid S/S RAIRANGPUR	3.09551971	VL
17	118	OD002	Odisha	220KV Budhipadar-Basundhara line	0.40467203	H
18	6	OD003	Odisha	SUNDARGARH GRID	0.05772723	M
19	10	OD004	Odisha	132/33KV GridS/S BARBIL	0.18062894	H
20	287	OD005	Odisha	Rairangpur-Polasponga Line	3.38266109	VL

21	12	OD006	Odisha	132kV PGCIL-Rairangpur line	1.94876772	VL
22	455	OD007	Odisha	220K.V. TTPS-JODA D/C Line.	0.20807289	H
23	22	OD008	Odisha	132/33KV GridS/S ,Palaspanga	0.23103323	H
24	NA	OD009	Odisha	Karanjia Grid S/S	1.03436158	VL
25	157	OD010	Odisha	Rairangpur-Polasponga Line	0.3743418	H
26	26/28	OD011	Odisha	132kV PGCIL-Baripada SC line	0.16981208	M
27	27	OD012	Odisha	Grid	0.10141527	M
28	28	OD013	Odisha	132/33KV GRID SUB-STATION,JALESWAR	0.5778667	H
29	29	OD014	Odisha	Grid S/S,Lapanga	NR	NR
30	NA	OD015	Odisha	132/33KV Grid S/S,Kuchinda	NR	NR
31	35/75	OD016	Odisha	132kv PALASPANGA-KEONJHAR TRACTION LINE	0.09831279	M
32	310	OD017	Odisha	400k.v. Rengali-Baripada S/C Line.	0.11074991	M
33	39	OD018	Odisha	Grid	0.09415381	M
34	40	OD019	Odisha	220/132/33KV GRID SUB-STATION,BALASORE	0.29272218	H
35	41	OD020	Odisha	132/33KV GRID SUB-STATION, BASTA	0.10059608	M
36	43	OD021	Odisha	BARGARH GRID	0.13950838	M
37	44	OD022	Odisha	Grid S/S,Katapali	0.57842518	H
38	45	OD023	Odisha	TLSS,Sambalpur(132kv Burla-Boinda transmission line)	0.12546249	M
39	65	OD024	Odisha	400k.v. Rengali-Baripada S/C Line.	0.18067666	H
40	146	OD025	Odisha	400k.v. Rengali-Baripada S/C Line.	0.17302114	M
41	55	OD027	Odisha	NA	0.29981429	H
42	206	OD028	Odisha	132KV BALASORE - SORO FEEDER	0.8731389	VL
43	58	OD029	Odisha	BARPALI GRID	0.1248929	M
44	60	OD030	Odisha	TLSS,Sambalpur(132kv Burla-Boinda transmission line)	0.334224	H
45	65/131	OD031	Odisha	220KV TTPS-JODA LINE, TL Sub Division, CHINPAL	0.25339407	H
46	66	OD032	Odisha	132/33 KV GRID SUB-STATION , KALARANGI.	0.48898249	H
47	67	OD033	Odisha	132 KV Bamanipal line	0.788169	H
48	68	OD034	Odisha	132/33KV GRID S/S, ANANDAPUR	0.24025408	H
49	NA	OD035	Odisha	grid location,Bhadrak	0.30977984	H
50	56	OD036	Odisha	132KV BHADRAK-SORO FEEDER	0.54901011	H
51	83	OD038	Odisha	220/132/33 KV GRID S/S,DUBURI	0.44293214	H
52	84	OD039	Odisha	132/33 KV Grid S/S Jajpur Road	0.28068304	H
53	85	OD040	Odisha	132/33KV GRID S/S JAJPUR TOWN	0.13771216	M
54	110	OD041	Odisha	132 KV DPCL-I &II	0.10956012	M

55	256	OD042	Odisha	132 KV DPCL-I &II	0.37219778	H
56	NA	OD043	Odisha	GRID SUBSTATION PATNAGARH	2.06367981	VL
57	NA	OD044	Odisha	GRID S/S BOLANGIR(OLD)	0.17685733	M
58	108	OD045	Odisha	132 KV DKL-MRDL line, OPTCL	0.18452346	H
59	NA	OD046	Odisha	132/33 KV DKL GRID S/S , OPTCL	0.52813079	H
60	102	OD047	Odisha	132 KV ICCL SW / SS , CHOUDWAR	0.21821495	H
61	103	OD048	Odisha	132/33 KV Grid Sub-Station Chandikhol, OPTCL	1.31772055	VL
62	NA	OD049	Odisha	132/33 kV Grid S/S, Kendrapara	0.28902751	H
63	NA	OD050	Odisha	132/33 kV Grid Sub-Station, Pattamundai	0.29019231	H
64	108	OD051	Odisha	132kv GRID,KHARIAR	0.20859568	H
65	NA	OD052	Odisha	132/33kV Grid S/S, Phulbani	0.49117784	H
66	213	OD053	Odisha	132kV Bhanjanagar-PhulbaniS/c line	0.34718192	H
67	265	OD054	Odisha	220kv bhanjanagar -meramundali D/C line	0.22181592	H
68	118	OD055	Odisha	132 KV GRID SUBSTATION, NUAPATNA, OPTCL	0.11021872	M
69	119	OD056	Odisha	GRID S/S MENDHASAL	0.15954672	M
70	NA	OD057	Odisha	NA	0.72614235	H
71	NA	OD058	Odisha	132 KV GRID SUBSTATION, JAGATSINGHPUR, OPTCL	0.34065281	H
72	234	OD059	Odisha	132KV Kendrapara-Paradeep DC line	0.07706833	M
73	NA	OD060	Odisha	220/132/33KV Grid S/S ,Paradeep	0.20488482	H
74	125/55	OD061	Odisha	132KV KESINGA-KHARIAR LINE	0.20736889	H
75	141	OD062	Odisha	132kV Bhanjanagar-PhulbaniS/c line	0.35528757	H
76	327	OD063	Odisha	220 KV BHANJANAGAR- MERAMUNDALI D/C LINE	0.23617071	H
77	135/319	OD064	Odisha	220kV Bhanjanagar-Mendhasal line	1.92134928	VL
78	NA	OD065	Odisha	132/33 KV GRID S/S KHURDA	0.97416775	VL
79	137	OD066	Odisha	NA	0.32556133	H
80	NA	OD067	Odisha	NA	3.88213492	VL
81	143/247	OD068	Odisha	132KV Therubali-Kesinga line	0.24515961	H
82	148	OD069	Odisha	Grid S/S, Bhanjanagar	1.75243692	VL
83	200	OD070	Odisha	132 KV KHURDA-BALUGAON SC LINE	0.97439209	VL
84	NA	OD071	Odisha	132/33 KV GRID S/S CHANDPUR	0.19723274	H
85	153	OD072	Odisha	132KV KHURDA PURI LINE	2.188101	VL
86	NA	OD073	Odisha	NA	4.29274256	VL
87	NA	OD074	Odisha	132/33KV Grid Sub-Station, Umerkote	1.32779389	VL
88	160/49	OD075	Odisha	132 kv LILO to Vedanta Alumina from therubali to kesinga line	0.70932543	H

89	161/142	OD076	Odisha	132kv Therubali-kesinga Line	0.20736889	H
90	583	OD077	Odisha	220 KV BHANJANAGAR- THERUVELI D/C LINE	0.15888777	M
91	NA	OD078	Odisha	BALUGAON GRID	1.16132587	VL
92	NA	OD079	Odisha	132/33KV Grid Sub-station, Dabugaon	0.3791264	H
93	172/164	OD080	Odisha	220kv Therubali-Indravati DC line	0.16909875	M
94	173	OD081	Odisha	220 KV GRID SUB-STATION, THERUBALI	2.7995752	VL
95	174/58	OD082	Odisha	220kv Therubali-Narendrapur DC line	0.19644036	H
96	175	OD083	Odisha	132/33KV Akhusinghi Grid S/S	0.94633599	VL
97	176	OD084	Odisha	132 KV MOHANA AKHUSING SC LINE	0.44581811	H
98	177	OD085	Odisha	132 KV MOHANA AKHUSING SC LINE	0.43922243	H
99	NA	OD086	Odisha	CHATRAPUR GRID	5.73584365	5.735843652
100	68	OD087	Odisha	132KV Jeypore T.S/s. to Ch. Kusumi T.S/s. line	0.66973666	H
101	430	OD088	Odisha	132KV Jayanagar-Rayagada S.C. line	0.75797603	H
102	184	OD089	Odisha	132/33KV grid S/S Rayagada	0.32151099	H
103	185/437	OD090	Odisha	132KV Rayagada- Akhusinghi S/C line	0.84492591	VL
104	186/181	OD091	Odisha	132 KV Akhusingh - Paralakhemundi Line	0.55419482	H
105	68	OD092	Odisha	132KV Jeypore T.S/s. to Ch. Kusumi T.S/s. line	0.54837727	H
106	272	OD093	Odisha	132KV Jayanagar-Rayagada S.C. line	0.82537148	VL
107	NA	OD094	Odisha	220/33KV grid S/S Laxmipur-	0.92634787	VL
108	194/87	OD095	Odisha	132 KV Akhusingh - Paralakhemundi Line	0.32436451	H
109	195/0	OD096	Odisha	132 KV Akhusingh - Paralakhemundi Line	0.28936819	H
110	71	OD097	Odisha	132KV Machkund-Jayanagar line	0.64362535	H
111	98	OD098	Odisha	132KV MKD P.House-MKD Road T.S/s. line	0.65616506	H
112	NA	OD099	Odisha	132/33KV Grid Sub-Station, Sunabeda	0.44259796	H
113	1689	OD100	Odisha	220KV Jayanagar- Balimela DC Line	1.63137667	VL
114	76	OD101	Odisha	132KV MKD Road T.S/s. to Padwa T.S/s. line	1.7631721	VL
115	206	OD102	Odisha	220/33 KV Grid S/S Balimela	1.61762281	VL
116	1134	ERO001	Odisha	400 KV D/C Rourkela - Raigarh I & II	0.01270866	**L**
117	972	ERO002	Odisha	400 KV D/C Rourkela-Raigarh I&II Transmission Line	0.01999098	**L**
118	1017	ERO003	Odisha	400 KV D/C Rourkela-Raigarh I &II line	0.05989602	M
119	400	ERO004	Odisha	400 KV D/C ROURKELA-TALCHER Transmission Line	0.01462042	**L**
120	675	ERO006	Odisha	400 KV D/C Rourkela -Raigarh I& II Transmission Line	0.01923945	**L**
121	771	ERO007	Odisha	400 KV D/C Rourkela -Raigarh I& II Transmission Line	0.01396874	**L**
122	850	ERO008	Odisha	400 KV D/C Rourkela -Raigarh I& II Transmission Line	0.0127925	**L**

123	318	ERO009	Odisha	400 KV D/C Talcher - Rourkela I & II	0.01534526	**L**
124	213	ERO010	Odisha	400 KV D/C Talcher - Rourkela I & II	0.01119572	**L**
125	28	ERO015	Odisha	400 KV Talcher-Meramundali D/C Line	0.24942062	H
126	225	ERO018	Odisha	400 KV Angul-Bolangir S/C Line	0.23285417	H
127	225	ERO019	Odisha	400 KV Angul-Bolangir S/C Line	0.19994511	H
128	129	ERO020	Odisha	400 KV Angul-Bolangir S/C Line	0.26392787	H
129	65	ERO022	Odisha	500 KV Talcher - Kolar HVDC Line	0.30138754	H
130	105	ERO023	Odisha	400 KV Talcher-Meramundali D/C Line	0.24527832	H
131	651 (B+0)	ERO024	Odisha	400 KV Rengali - Indraabati S/C Line	0.42731715	H
132	688 (A+3)	ERO026	Odisha	400 KV BAlangir-Jeypore S/C Line	0.42482898	H
133	245	ERO027	Odisha	500 KV Talcher - Kolar HVDC Line	0.1875265	H
134	433	ERO030	Odisha	500 KV Talcher - Kolar HVDC Line	0.20603	H
135	356	ERO031	Odisha	500 KV Talcher - Kolar HVDC Line	0.12823148	M
136	500	ERO034	Odisha	500 KV Talcher - Kolar HVDC Line	0.05305406	M
137	628	ERO036	Odisha	500 KV Talcher - Kolar HVDC Line	1.20817522	VL
138	581	ERO037	Odisha	500 KV Talcher - Kolar HVDC Line	1.28195144	VL
139	673	ERO040	Odisha	500 KV Talcher - Kolar HVDC Line	0.23970645	H
140	768	ERO042	Odisha	500 KV Talcher - Kolar HVDC Line	0.73953115	H
141	191	OD026	Odisha	400k.v. Rengali-Baripada S/C Line.	0.11340304	M
142	259	OD037	Odisha	132KVBargaerh -Bolangir Line	1.05397827	VL
143	1135	ERO001 01	Odisha	400 KV D/C Rourkela-Raigarh I & II Transmission Line	0.01745462	**L**
144	332	ERO009 09	Odisha	400 KV D/C Talcher - Rourkela I & II	0.01468874	**L**
145	194	ERO010 10	Odisha	400 KV D/C Talcher - Rourkela I & II	0.0155437	**L**
146	107	ERO11	Odisha	400 KV Talcher-Rourkela D/CTransmission Line	0.04219986	**L**
147	931	ERO12	Odisha	400 KV RENGALI-INDRAVATI S/C Transmission Line	0.0142278	**L**
148	1021	ERO13	Odisha	400 KV RENGALI-INDRAVATI S/C Transmission Line	0.01262315	**L**
149	1078	ERO14	Odisha	400 KV RENGALI-INDRAVATI S/C Transmission Line	0.05921581	M
150	464	ERO16	Odisha	400 KV Angul-Bolangir S/C Transmission Line	0.00905123	VL
151	371	ERO17	Odisha	400 KV Angul-Bolangir S/C Transmission Line	0.0148831	**L**
152	547 (B+0)	ERO24	Odisha	400 KV Balangir-Jeypore S/C Line	0.04747968	M
153	688 (A+3)	ERO26	Odisha	400 KV BAlangir-Jeypore S/C Line	0.04720322	M
154	1131 (A+6)	ERO38	Odisha	400 KV Jeypore - Bolangir S/C Line	0.09647332	M
155	1187 (A+0)	ERO41	Odisha	400 KV JeyporeBolangir S/C Line	0.10636733	M

156	37 (A+3)	ERO43	Odisha	400 KV Jeypore - Indravati S/C Line	0.07801254	M
157	651(B+0)	ERO024 024	Odisha	400 KV Rengali - Indraabati S/C Line	0	0
158	948	ERO039 039	Odisha	400 KV S/C Bolangir – Jeypore Transmission Line	0	0
159	948	ERO032 032	ODISHA	400 KV S/C Bolangir – Jeypore Transmission Line	0.08941736	M

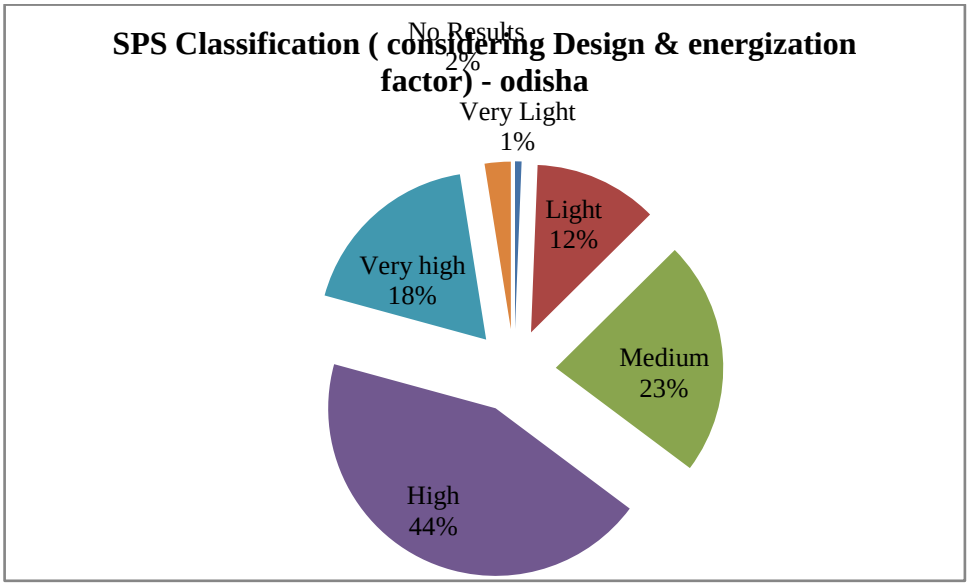

Fig. 5 Percentile Variation of SPS Classification (considering Design & energization factor) - Odisha

5.5 Site Pollution Severity (SPS) Classification for Sikkim

Table 8 represents maximum SPS levels achieved on each testing stations out of six pollution measurements. Figure 6 represents the percentile variation of SPS measurements (measured & recommended SPS to be considered).

Note: The severity class for the sites in which ESDD/NSDD measurements have not been received is represented as No Results (NR).

Table 8. Site Pollution Severity (SPS) Classification for Sikkim

Sl.No	Location No	*UID*	*State*	*Latitude*	*Longitude*	*Name of the transmission line*	Maximum Average ESDD (Considering design &Energization factor)	SPS Classification (considering Design & energization factor)
1	170	NA	Sikkim	27*.3636	88*.2173	Rimbi- Yuksum 11KV line	0.016384999	**L**
2	NA	NA	Sikkim	NA	NA	Chungthang-Thangu 11KV line	0.024551822	**L**
3	NA	NA	Sikkim	27.496944	88.533889	Phudong- Mangan 6KV line	0.02465964	**L**
4	161 (DDL+6)	NA	Sikkim	27° 11.242"	88° 22.498"	132 kV Rangpo - Gangtok D/C Line	0.004356762	VL
5	32 DBR+9	NA	Sikkim	27° 2.121"	88° 18.076"	132 kV SiliguriMelli Line	0.004356762	VL
6	212	SIK002	Sikkim	27.606111	88.649722	ManganChungthang 11KV line	0.136483473	M
7	NA	SIK003	Sikkim	27.254826	88.140964	Dentam 11/11 S/S	0.115902932	M
8	NA	SIK004	Sikkim	27.293056	88.250278	Gyalshing - RagitSaagbari 132 Kv	0.115487416	M
9	NA	SIK005	Sikkim	27.318088	88.595948	Tadong Switch Yard	0.112429333	M
10	NA	SIK007	Sikkim	27.2436	88.2700	Namchi -Gyalshing	0.104672637	M
11	NA	SIK007	Sikkim	27.0859	88.45208	132/66KV	0.021804825	**L**

						swtichYard		
12	NA	SIK007	Sikkim	27.17733	88.363505	Namchi Switch Yard	0.03762653	**L**
13	NA	SIK008	Sikkim	27.210515	88.68847	Rongli Switch Yard	0.121021414	M
14	161		SIKKIM	27'11.242"	88'22.498"	132KV Rangpo-Gangtok D/C Line	0.00444382	VL
15	32		SIKKIM	27'2.121"	88'18.076"	132KV SiliguriMelli Line	0.004356762	VL
16		SIK001	SIKKIM	27.56673	88.416704	MANGAN - SAKYONG PENTONG 11KV line	0.012429729	M
17	NA	SIK007-02	SIKKIM	27.2436	88.2700	Namchi -Gyalshing	0.045464375	M
18	NA	SIK009	SIKKIM	27.9121	88.537	Chungthang-Thangu 11KV line	0.031607953	**L**

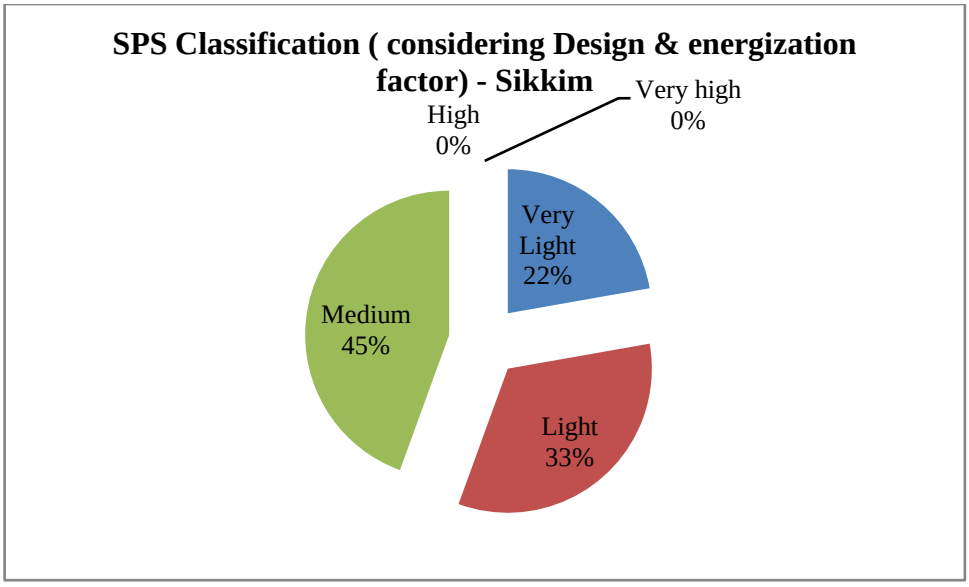

Fig. 6 Percentile Variation of SPS Classification (considering Design & energization factor) - Sikkim

5.6Site Pollution Severity (SPS) Classification for West Bengal

Table 9 represents maximum SPS levels achieved on each testing stations out of six pollution measurements. Figure 7 represents the percentile variation of SPS measurements (measured & recommended SPS to be considered).

Note: The severity class for the sites in which ESDD/NSDD measurements havenot been received isrepresented as No Results (NR).

Table 9.Site Pollution Severity (SPS) Classification for West Bengal

Sl. No	Location No	*UID*	*State*	*Latitude*	*Longitude*	*Name of the transmission line*	Maximum Average ESDD (Considering design & Energization) factor	SPS Classification (considering Design & energization factor)
1	170	ER030	West Bengal	26° 46´ 6.6"	87° 02´ 29.7"	400KV Maithon-Jamshedpur	0.081383746	M
2	260	ER035	West Bengal	19.6373	82.8928	400 KV S/C Indravati – Rengali Transmission Line	0.070150288	M
3	303	ER183	West bengal	23.42123333	85.97741667	400KV RANCHI-Maithan (RB) D/C LINE	0.071832736	M
4	303	ER183	West Bengal	23.42123333	85.97741667	400KV RANCHI-Maithan (RB) D/C LINE	0.003584866	VL
5	235	ER2001	West Bengal	26˚52.002'	88˚15.245'	132 KV Siliguri-Rangeet D/C TL	0.272914351	H
6	317	ER2002	West Bengal	26˚41.322'	88˚22.229'	132 KV Siliguri -Rangeet D/C TL	0.482512326	H
7	536	ER2003	West Bengal	26˚33.896'	88˚34.693'	400 KV NSLG-Bongaigaon D/C TL	0.09354928	M
8	252	ER2004	West Bengal	26˚34.771'	88˚51.147'	400 KV New Siliguri-Tala-1 D/C TL	0.102128275	M
9	161	ER2005	West Bengal	N 26º41'36.6"	E 89º06'26.1"	400KV Tala-New Siliguri Line-I	0.080007098	M
10	74	ER2006	West Bengal	N 26º 46' 07.3"	E 89º 20' 28.5"	220 KV BRP-CHPC D/C	0.062821294	M
11	662	ER2007	West Bengal	26˚26.060'	88˚17.338'	400 KV New Siliguri-Purnea D/C TL	0.218214952	H
12	301	ER2008	West Bengal	26°29'51.53"N	89°21'25.13"E	400KV Bongaigaon-New Siliguri Line	0.079544684	M

13	208	ER2009	West Bengal	26°26'19.00"N	89°40'57.30"E	400KV Bongaigaon-New Siliguri Line	0.169986374	M
14	23	ER2011	West Bengal	NA	NA	400 KV NSLG-NPRN D/C TL	0.370265696	H
15	933	ER2012	West Bengal	NA	NA	400 KV New Purnea-Malda D/C TL	0.118094962	M
16	137	ER2013	West Bengal	25˚23'57.9''	88˚09'28.5''	220 KV KVMaldaDalkhola Line	0.33673848	H
17	1112	ER2014	West Bengal	25˚5'53.3''	88˚6'45.4''	400 KV MaldaFarakka Line	0.394096406	H
18	55	ER2015	West Bengal	24˚52 ' 41.1''	88˚00' 36.2''	400 KV MaldaFarakka Line	0.334201579	H
19	67	ER2016	West Bengal	24.533558	87.933401	400 KV S/C Farakka-SagardighiTranmission Line	0.239755453	H
20	90	ER2017	West Bengal	24.466856	87.966724	400 KV S/C Farakka-SagardighiTranmission Line	0.311920146	H
21	162	ER2018	West Bengal	24 16.348'	88 04.960'	400 KV S/C Sgtpp-SubhasgramTranmission Line	0.238862929	H
22	210	ER2019	West Bengal	24.050199	87.700126	400 KV S/C Farakka-Durgapur # I Tranmission Line	0.238416814	H
23	171	ER2020	West Bengal	24.183595	87.766794	400 KV S/C Farakka-Durgapur # I Tranmission Line	0.237970799	H
24	185	ER2021	West Bengal	24 11.776'	88 06.777'	/C Farakka-JeerutTranmission Line	0.237524886	H
25	278	ER2022	West Bengal	23.882583	87.611917	400 k v S/c farakka-durgapur-1	0.237079076	H
26	263	ER2023	West Bengal	23 56.740'	88 10.168'	400 KV S/C Sgtpp-SubhasgramTranmission Line	0.306345827	H
27	369	ER2025	West Bengal	23.632417	87.403167	400 k v Farakka-Durgapur-1	0.236187769	H
28	387	ER2026	West Bengal	23.589722	88.344583	400KV S/C Jeerat - Beherampur TL	0.30644097	H
29	387	ER2026	West Bengal	23.589722	88.344583	400KV S/C Jeerat - Beherampur TL	NR	NR
30	220	ER2029	West Bengal	23.33349	86.433487	400 kv D /C Maithon - JamshedpurLine	0.294734789	H

31	170	ER2030	West Bengal	26° 46´ 6.6"	87° 02´ 29.7"	400KV Maithon-Jamshedpur	0.587843997	H
32	123	ER2031	West Bengal	23.362389	87.143972	400 k v S/C Durgapur-Jamshedpur	0.242882262	H
33	55	ER2032	West Bengal	23.460972	87.35725	400 k v S/C Durgapur-Jamshedpur	0.289379199	H
34	446	ER2033	West Bengal	23.408333	88.431028	400KV S/C Jeerat - Beherampur TL	0.248769983	H
35	446	ER2033	West Bengal	23.408333	88.431028	400KV S/C Jeerat - Beherampur TL	NR	NR
36	290	ER20335	West Bengal	23.135278	86.623444	400 kv S/c Durgapur Jamshedpur	NR	NR
37	290	ER2035	WEST BENGAL	23.135278	86.623444	400 kv S/c Durgapur Jamshedpur	0.249226368	H
38	220	ER2036	West Bengal	23.232944	86.861833	400 k v s/C Durgapur-Jamshedpur	0.030170689	**L**
39	540	ER2037	West Bengal	23.147472	88.565583	400KV S/C Jeerat - Beherampur TL	0.290089655	H
40	540	ER2037	West Bengal	23.147472	88.565583	400KV S/C Jeerat - Beherampur TL	NR	NR
41	611	ER2038	West Bengal	22.911667	88.580806	400KV S/C Jeerat - Beherampur TL	0.250139399	H
42	611	ER2038	West Bengal	22.911667	88.580806	400KV S/C Jeerat - Beherampur TL	NR	NR
43	162	NA	West Bengal	23.32848	86.34009	400KV RANCHI-Maithan D/C LINE	0.02629858	**L**
44	89	NA	West Bengal	23.38772	86.45158	400KV RANCHI-Maithan D/C LINE	0.039779293	**L**
45	128	NA	West Bengal	N 24.40.629 or 24.666841	E 87.52.996 or 87.866943	400 KV S/C Farakka-Durgapur # I Tranmission Line	NR	NR
46	43	NA	West Bengal	23.736041	87.5185563	400 kV Bakreswar - Jeerat Single Ckt. Trans. Line.	0.071101782	M

47	745	NA	West Bengal	26° 12.601′	88° 12.064′	400 kV New Siliguri -Purnea D/C TL Line	0.033241651	**L**
48	142	NA	West Bengal	24° 19.121′ / 24.3167	86° 03.188′ / 88.050052	400 kV S/C Farakka - Sagardighi Transmission Line	NR	NR
49	9	NA	West Bengal	24° 44.458′ / 24.733461	87° 53.527′ / 87.88348	400 kV S/C Farakka - Sagardighi Transmission Line	NR	NR
50	311	RM311	West Bengal	23°25.146' or 23.4191	86°06.133' or 86.10221	400KV RANCHI-Maithan D/C LINE	0.063726694	M
51	77	WB001	West Bengal	22.865	88.6222	Chalsa- Odlabari 66 kV	0.311056044	H
52	139	WB002	West Bengal	26.855	88.804	Chalsa NJP 132 kV Line	0.241104048	H
53	NA	WB003	West Bengal	26.6488	89.7246	33 kV Kartica Sub-station	0.376625604	H
54	1	WB005	West Bengal	25.406809	87.866937	WBSEDCL	0.30799614	H
55	NA	WB008	West Bengal	25.0754	87.9091	33 KvManikchak substation	0.168786328	M
56	NA	WB009	West Bengal	25.1259	88.36556	Gunnagar, 33 kV Sub-Station,WBSEDCL	0.311056048	H
57	64	WB010	West Bengal	24.082201	88.272997	132 kV Berhampore- Gokarna D/C Line	0.241104048	H
58	NA	WB011	West Bengal	24° 07′ 15.6"	88° 39′ 52.3"	VHF Tower of Jalangi 33 kV S/S	0.135524421	M
59	1	WB013	West Bengal	23° 58′ 09.8"	87° 57′ 53.0"	132 kV Gokarna- Kuli& 132 kV Kuli-Sainthia	0.088028398	M
60	1	WB014	West Bengal	23° 55′ 32.6"	88° 26′ 31.7"	132 kV Amtala- Nazirpur Circuit - I & II	0.079794647	M
61	260	WB016	West Bengal	23° 36′ 54.36"	87° 8′ 52.1376"	DGP, STPS & DGP-ANSI 220 D/C Line	0.273131346	H
62	80	WB017	West Bengal	23.6667	87.7167	132 kV Bolpur-Sainthia Double Ckt. Trans. Line	0.169070096	M

63	6	WB019	West bengal	23.639722	88.110278	220KV Domjur-Arambag D/C Transmission Line	0.205661269	H
64	150	WB020	West Bengal	23° 26′ 53.9"	86° 46′ 53.2"	Bankura -Raghunathpur 132 kV D/C Line	0.059952152	M
65	1	WB021	West Bengal	NA	NA	MankarMahachanda TL No. 1	0.143357598	M
66	1	WB021	West Bengal	23.424	87.55	Mankar- Mahachanda TL No.1	0.143358579	M
67	1	WB022	West Bengal	23° 15′ 58.632"	88° 09′ 01.366"	132 kV Satgachiakatwa Double Ckt. Line	0.135525068	M
68	249	WB024	West Bengal	23° 11′ 38.1"	86° 04′ 15.8"	Purulla - Bagmundi 132 kV S/C Line	0.898800437	VH
69	1	WB026	West Bengal	23.085298	87.312634	Bishnupur-Katra D/C Line	0.085577866	M
70	340	WB027	West Bengal	23° 12'	87° 35'	Arambag-Tarakeswar 132 kV Line	0.584065916	H
71	3	WB030	West Bengal	23.05861	88.3197	132 kV Satgachia-Kahayan-BTPS Transmission Line	0.463813366	H
72	1	WB031	West Bengal	23.186389	88.856389	Helencha 33 kV Line	0.649248691	H
73	NA	WB032	West Bengal	22.9974219	86.64722799	NA	0.167016419	M
74	260 (45/0)	WB033	West Bengal	22.968884	86.870913	Khatra-Bishnupur 232 kv D/C Tr Line	0.88865008	VH
75	79	WB034	West Bengal	22° 56′ 17.7" (22.93825°)	87° 21′ 37.2" (87.36033°)	Midnapore- Bishnupur 132 kV D/C Line	1.123500546	VH
76	NA	WB035	West Bengal	22° 53'	87° 42'	Inside Arambg 400 kV Substation	0.11836667	M
77	1	WB036	West Bengal	22.863	87.92	Arambag- Durgapur 400 kV Line	0.118409473	M
78	56	WB037	West Bengal	22° 55' 59.157 '' N	88° 8' 44.971 '' N	132kV Tarakeshwar-Belmuri D/C Line	0.079871932	M
79	NA	WB039	West	22° 34′	86° 55′ 16"	Binpur 33 kV Sub-station	0.112221804	M

			Bengal	26.5"				
80	NA	WB040	West Bengal	NA	NA	Goaltore 33 kV Substation/VHF Tower	0.649248691	H
81	220	WB041	West Bengal	22° 39′ 1.6"	87° 19′ 27"	Midnapore- C.K.Road-Bishnupur 132 kV D/C Line	0.16383403	M
82	91	WB042	West Bengal	22° 43′ 27.3" (22.72425°)	87° 39′ 45.3" (87.66258°)	Arambagh-Birsingha 132 kV D/C Line	0.710920064	H
83	6/0	WB044	West Bengal	22° 39′ 10.49"	88° 10′ 54.38"	220 kV Domjur - Arambhag D/C Transmission Line	0.43303962	H
84	139	WB046	West Bengal	22.677809	88.835425	Ashokenagar-Basirhat D/C Line	0.061094168	M
85	NA	WB047	West Bengal	22° 16′ 53.9"	86° 52′ 22.1"	Chilkigarh 33 kV Substation VHF/Tower	0.176146788	M
86	161	WB048	West Bengal	22° 26′ 55.7" (22.44880°)	87° 01′ 33.8" (87.026055°)	Midnapore-Jhargram 132 kV Double Circuit Line	0.123098536	M
87	50	WB049	West Bengal	22° 21' 54 ''	87° 17' 45 "	MID-KGP WBIIDC 132 kV D/C Line	0.243289661	H
88	67	WB050	West Bengal	22° 23′	87° 30′ 25"	Midnapore-Balichalk 132 kV Transmission Line	0.163290362	M
89	12A/0	WB051	West Bengal	22.47	87.97	KTPP Bagnan 132 kV Line	0.433039597	H
90	NA	WB054	West Bengal	22.4725	88.97222	Hingalgang 33 kV S/S	0.06762792	M
91	NA	WB055	West Bengal	22° 12′ 24.3"	86° 53′ 43.7"	Gopiballavpur 33 kV sub-station / VHF Tower	0.467251976	H
92	NA	WB056	West Bengal	NA	NA	Sankrail 33 kV Sub-station	0.120512111	M
93	65	WB057	West Bengal	22° 12' 30''	87° 22' 26''	EGRA-BEL-HIZLI 132 kV S/C Line	0.400982637	H
94	63	WB058	West Bengal	22° 14' 4.2'' N	87° 35' 3.2'' N	132 kV Midnapur- Pingla D/C Line	0.086337221	M
95	28	WB069	West	23.34899	87.8673	132 kV Satgachia-	0.1971308	H

			Bengal			Mahachanda Double Ckt Line		
96	128		WEST BENGAL	24.666841	87.866943	400 KV S/C Farakka-Durgapur # I Tranmission Line	NR	NR
97	301		WEST BENGAL	26°29'51.53"	89°21'25.13"	400KV Bongaigaon-New Siliguri Line	0.075634988	M
98	23		West Bengal	687.8457143	774.6604082	400 KV NSLG-NPRN D/C TL	0.021379074	**L**
99	263		WEST BENGAL	23 56.740'	88 10.168'	400 KV S/C Sgtpp-SubhasgramTranmission Line	NR	NR
100	170		WEST BENGAL	26° 46´ 6.6"	87° 02´ 29.7"	400KV Maithon-Jamshedpur	0.048830247	M
101	252		West Bengal	26˚34.771'	88˚51.147"	400 KV New Siliguri-Tala-1 D/C TL	0.008397485	VL
102	1112		West Bengal	25˚5'53.3''	88˚6'45.4''	400 KV MaldaFarakka Line	0.037220203	**L**
103	745	ER2010	West Bengal	26.200167	88.200018	400 KV New Siliguri-Purnea D/C TL	0.050867452	M
104	65	ER2039	West Bengal	22.705139	88.605444	400KV S/C Jeerat - Subhasgram D/C TL	0.250596043	H
105	163	ER2040	West Bengal	22.42392	88.47342	400KV Subhasgram - Jeerat D/C TL	0.143151551	M
106	282	WB065	West Bengal	21.776˚N	87.724˚E	NHAL-Egra 132 KV D/C LILO at Contai	0.122682374	M
107	196	WB066	WEST BENGAL	21.989	87.779	NHAL-Egra 132 KV D/C LILO at Contai	0.307996135	H
108		WB068	WEST BENGAL	21.632	87.515	Digha 33KV SS	0.028232512	**L**
109	9	ER201601	West Bengal	24.7334	87.8834	400 KV S/C Farakka-SagardighiTranmission Line	0.075730898	M
110	128	ER2016	West	24.6668	87.8669	400 KV S/C Farakka-Durgapur	0.081725086	M

		02	Bengal			# I Tranmission Line		
111	TL-73	WB060	West Bengal	22.0300˚ N	88.060˚E	132KV HALDIA - HALDIA NIZ D/C LINE	0.531417394	H

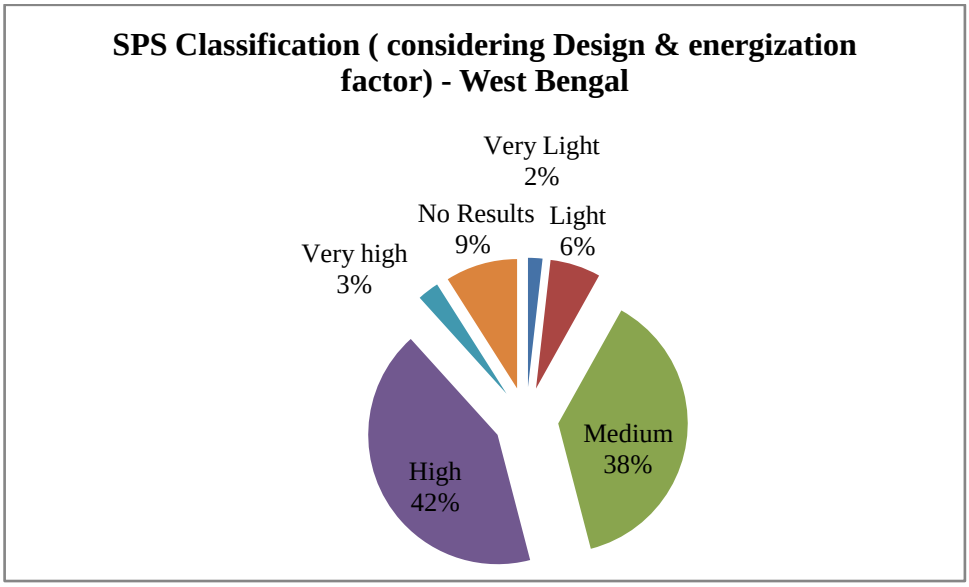

Fig. 7 Percentile Variation SPS Classification (considering Design & energization factor) - West Bengal

5.7Seasonal variation of pollution level

Changes in the measured SPS class over a period of two years for selected locations aredepictedfrom Fig8to 33.From the above mentioned figures, it is evident that SPS level varies periodically.

Transmission Line	Voltage	Tower Location Number	Unique ID
132kV Ramnagar - Valmikinagar trans line	132kV	101	BP001

Measurement No.	ESDD	Severity
1	NR	NR
2	NR	NR
3	NR	NR
4	0.2418374	H
5	0.0731217	M
6	0.1062895	M

Transmission Line	Voltage	Tower Location Number	Unique ID
132kv Dhaka-Sitamarhi line	132kV	12	BP007

Measurement No.	ESDD	Severity
1	0.1176939	M
2	NR	M
3	0.1176939	M
4	0.0801755	M
5	0.1005952	M
6	0.1155177	M

Transmission Line	Voltage	Tower Location Number	Unique ID
220KV D/C LOHARDAGA-LATEHAR	220kV	66	JUS10

Measurement No.	ESDD	Severity
1	0.027975	L
2	0.083924	M
3	0.251771	H
4	0.7553125	H
5	2.2659374	VH
6	6.7978121	VH

Transmission Line	Voltage	Tower Location Number	Unique ID
220KV D/C LOHARDAGA-LATEHAR	220kV	5	JUS12

Measurement No.	ESDD	Severity
1	0.030812	L
2	0.092436	M
3	0.277307	H
4	0.8319224	VH
5	2.495767	VH
6	7.4873018	VH

Transmission Line	Voltage	Tower Location Number	Unique ID
400 KV S/C Bolangir – Jeypore Transmission Line	400kV	810	ERO028

Measurement No.	ESDD	Severity
1	0.067283	M
2	0.063243	M
3	0.068584	M
4	0.0743978	M
5	0.0897318	M
6	0.0320797	M

Transmission Line	Voltage	Tower Location Number	Unique ID
132KV MKD Road T.S/s. to Padwa T.S/s. line	132kV	76	OD101

Measurement No.	ESDD	Severity
1	0.065303	M
2	0.195908	H
3	0.587724	H
4	1.7631721	VH
5	0.0797714	M
6	0.239314	H

Transmission Line	Voltage	Tower Location Number	Unique ID
ManganChungthang 11KV line	11kV	212	SIK002

Measurement No.	ESDD	Severity
1	0.026468	L
2	0.079403	M
3	NR	NR
4	0.0151648	L
5	0.0454945	M
6	0.1364835	M

Transmission Line	Voltage	Tower Location Number	Unique ID
Rongli Switch Yard	-	-	SIK008

Measurement No.	ESDD	Severity
1	0.04034	L
2	0.121021	M
3	NR	NR
4	NR	NR
5	0.0982237	M
6	NR	NR

Transmission Line	Voltage	Tower Location Number	Unique ID
400 KV New Siliguri-Tala-1 D/C TL	400kV	252	ER2004

Measurement No.	ESDD	Severity
1	0.014083	L
2	0.039462	L
3	0.102128	M
4	0.0920356	M
5	0.0885067	M
6	0.0536147	M

Transmission Line	Voltage	Tower Location Number	Unique ID
220KV Domjur-Arambag D/C Transmission Line	132kV	6	WB019

Measurement No.	ESDD	Severity
1	NR	NR
2	NR	NR
3	NR	NR

4	0.2418374	H
5	0.0731217	M
6	0.1062895	M

5.8 Results of Chemical Analysis on NSDD congregated

The results of chemical analysis performed on non-soluble deposits accumulated are provided in the Table 10.

Table 10

Results of Chemical Analysis

Sl. No.	Sample details		Chemical composition (Oxide %)								
	HV LAB	MTD	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	Fe_2O_3	ZnO
1	132KV KHURDA PURI LINE	S0324	-	2.72	15.58	55.70	2.32	8.50	-	11.41	3.76
2	132/33 KV GRID SUBSTATION PATNAGARH	S0325	0.48	2.36	14.47	59.38	2.39	5.73	1.02	11.73	2.44
3	132/33 KV GRID SUBSTATION BASTA	S0326	0.36	2.20	15.93	58.06	2.37	10.71	1.19	9.18	-
4	400/220KV GRID S/S MENDHASAL	S0327	0.41	2.45	16.02	62.75	2.54	3.85	0.56	11.42	-
5	4132/33KV GRID-SUB STATION Karanjia	S0328	-	6.90	29.42	57.15	0.39	0.27	1.45	3.34	1.08
6	400KV BIHARSHARIF-MUZAFFARPUR	S0329	-	2.68	16.20	59.60	3.83	9.16	1.02	7.51	-
7	800KN HVDC-SAHARA-GOPALGUNG TL	S0330	0.72	3.01	15.75	53.48	4.10	14.53	0.65	7.66	-
8	400KV BIHARSHARIF-MUZAFFARPUR	S0331	0.68	3.20	17.54	56.43	4.35	9.17	0.64	7.99	-

9	800KV HVDC SAHARA-GOPALGUNJ TL	S0332	0.70	2.87	14.10	48.30	3.25	23.40	0.22	6.06	1.10
10	132KV BEHRAMPORE-GOKARNA D/C LINE	S0333	1.05	3.44	15.63	57.13	3.52	6.11	1.11	10.08	1.60
11	33KV JALANGI SUBSTATION	S0334	-	1.46	15.05	59.21	2.85	8.56	-	12.87	-
12	132KV GOKARNA-KULI & 132KV KULI-SAINTHIA	S0335	-	2.90	15.99	62.66	2.67	6.21	-	9.57	-

Sl. No.	Sample details		Chemical composition (Oxide %)								
	HV LAB	MTD	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	Fe_2O_3	ZnO
13	1132/33KV GRID S/S, KENDRAPARA	S0336	-	2.03	16.13	61.50	2.70	5.51	1.15	10.98	-
14	1TLSS, SAMBALPUR GRID SS	S0337	0.98	2.62	15.40	57.58	2.56	4.15	0.75	8.87	7.10
15	220KVGRID SUB-STATION, THERUBALI	S0338	-	-	18.09	54.37	-	6.06	-	11.91	9.57
16	32/33KV GRID-SUB STATION, KALARANGI	S0339	-	-	21.24	59.44	3.0	1.67	-	14.65	-
17	132/33KV GRID SUB-STATION, PATTAMUNDAI	S0340	-	2.53	14.01	56.06	2.50	12.46	-	10.85	1.60
18	132/33KV GRID S/S JAIPUR ROAD	S0341	-	2.86	15.94	54.53	2.33	6.83	1.21	11.91	5.12
19	220/132/33KV GRID S/S , DUBURI	S0342	0.45	2.61	16.47	55.78	2.22	6.21	1.69	10.11	4.46
20	132KV BEMANJPAL LINE	S0343	0.85	1.91	15.84	57.47	2.23	11.07	1.33	9.31	-

21	132KV AMTALA-NAZIRPUR CIRCUIT-I & II	S0344	-	2.62	15.42	62.25	2.52	4.21	1.14	11.83	-
22	1220KV D/C LOHARDAGA-LATEHAR	S0345	0.33	8.29	26.43	55.50	0.35	0.76	1.23	4.62	2.50
23	220KV D/C LOHARDAGA-LATEHAR	S0346	0.36	2.10	18.07	62.74	3.09	1.60	1.37	10.67	-
24	132KV HATIA PTPS	S0347	0.34	1.28	19.62	61.51	2.69	1.21	1.23	11.55	0.57

Sl. No.	Sample details		Chemical composition (Oxide %)								
	HV LAB	MTD	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	Fe_2O_3	ZnO
25	132KV LINE BAY NO. 01(132/33KV GSS SIMDEGA)	S0348	-	1.51	17.41	62.83	3.72	1.99	1.15	11.39	-
26	132KV S/C KAMDARA-GUMLA	S0349	-	1.89	18.43	63.23	3.24	1.73	0.88	10.60	-
27	132KV S/C KAMDARA-GUMLA	S0350	-	2.09	17.57	59.71	2.92	1.77	1.17	11.33	3.44
28	NIMAPARA GRID SUBSTATION	S0351	-	2.40	15.83	64.73	3.17	4.19	0.67	9.01	-
29	400KV BALANGIR-JEYPORE S/C LINE	S0352	-	3.43	14.28	51.49	1.82	18.95	-	10.03	-
30	400KV BALANGIR-JEYPORE S/C LINE	S0353	-	-	20.64	59.50	0.82	4.82	-	14.22	-
31	132/33KV GRID S/S ANANDPUR	S0354	-	3.17	15.75	59.89	2.25	6.30	-	12.64	-

5.9Discussions on chemical analysis of pollutants on the insulator surface

Based on the observations from chemical analysis, the content of Silica (Silicon Oxide) and Alumina (Aluminium Oxide) were predominantly present in most parts.The presence of silica and alumina is an outcome of dust collected on the insulator. Substantial amounts of Iron oxide and Calcium oxide were also present. Small quantities of oxides of Sodium, Magnesium, Potassium, Titanium and Zinc were observed in the pollutant samples.In few pollutant samples, chlorine, oxides of sulphur, nickel oxide, phosphorous and copper presence was observed.It is advisedto enforce strict regulations to refrain establishment of pollution sources near transmission towers.

5.11Discussions on layer conductance measurements on insulator string

CPRI proposed the measurement of layer conductivity at the end of sixth measurement to observe and compare the severity level withthe brush wash method.It is to be noted that, most of the received layer conductivity measurements were from fifth set of measurement. From Table 11, it is observed that there are some discrepancies between layer conductivity and brush wash method. Further investigation has to be carried out on the same.

5.12Geographical representation of pollution Severity

The pollution severity levels measured at the on-field condition wereportrayed on the geographical map of India. It is to be noted that the displayed severity class in the map is a step higher than the actual site severity measured. The above methodology is adopted to avoid un-wanted disturbances in the EASTERN grid.

Maps are to be included.

6 Plotting of Pollution regions using Interpolation technique

6.1 Interpolation Technique

Interpolation predicts values for cells in a raster from a limited number of sample data points. It can be used to predict unknown values for any geographic point data, such as elevation, rainfall, chemical concentrations, and noise levels.

6.2Inverse Distance Weighted

The IDW (Inverse Distance Weighted) tool uses a method of interpolation that estimates cell values by averaging the values of sample data points in the neighborhood of each processing cell.

The closer a point is to the center of the cell being estimated, the more influence, or weight; it has in the averaging process.

IDW interpolation determines cell values using a linearly weighted combination of a set of sample points. The weight is a function of inverse distance. The surface being interpolated should be that of a locationally dependent variable. Figure 39 represents the IDW neighborhood for selected point.

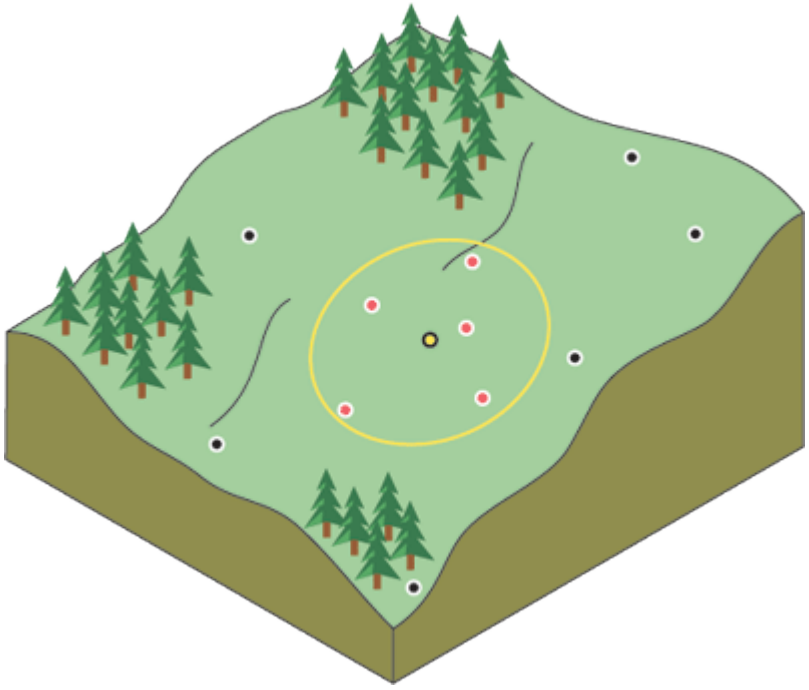

Fig. 39IDW neighborhood for selected point

This method assumes that the variable being mapped decreases in influence with distance from its sampled location. For example, when interpolating a surface of consumer purchasing power for a retail site analysis, the purchasing power of a more distant location will have less influence because people are more likely to shop closer to home.

6.3 Controlling the influence with the Power parameter

IDW relies mainly on the inverse of the distance raised to a mathematical power. The power parameter lets you control the significance of known points on the interpolated values based on their distance from the output point. It is a positive, real number, and its default value is 2.

By defining a higher power value, more emphasis can be put on the nearest points. Thus, nearby data will have the most influence, and the surface will have more detail (be less smooth). As the power increases, the interpolated values begin to approach the value of the nearest sample

point. Specifying a lower value for power will give more influence to surrounding points that are farther away, resulting in a smoother surface.

Since the IDW formula is not linked to any real physical process, there is no way to determine that a particular power value is too large. As a general guideline, a power of 30 would be considered extremely large and thus of questionable use. Also keep in mind that if the distances or the power value are large, the results may be incorrect.An optimal value for the power can be considered to be where the minimum mean absolute error is at its lowest.

6.4 Limiting the points used for interpolation

The characteristics of the interpolated surface can also be controlled by limiting the input points used in the calculation of each output cell value. Limiting the number of input points considered can improve processing speeds. Also consider that input points far away from the cell location where the prediction is being made may have poor or no spatial correlation, so there may be reason to eliminate them from the calculation.

6.5 Pollution mapping using IDW interpolation

The pollution map generated using IDW interpolation for the EASTERN region is given in Figure 40.

7.0 CONCLUSIONS

1. Site severity measurements were carried out near towers carrying HV lines. The procedure is repeated for two years covering varying seasonal changes. It is witnessed that the pollution levels reported from sites vary from low to very high in the EASTERN region of India.It is recommended to design and select insulators corresponding to the minimum specific creepage distance. Table 12 shows the minimum specific creepage distance recommended based upon the pollution severity obtained.

Table 12Percentile variation of Site Pollution Severity and Minimum Specific Creepage Distance required

Site Name	Pollution Severity in Percentile (Design Factor)					Minimum Specific Creepage Distance Required (mm/kV)
	VH	H	M	L	NR	
Bihar	15	35	29	4	17	28 – 31
Jharkhand	11	37	16	2	34	25 – 31
Odisha	5	34	34	5	22	20 – 28
Sikkim	2	16	33	13	36	20 – 28
West Bengal	0	20	60	20	0	20 – 28

2. Results obtained from chemical analysis shows oxides of Sodium, Magnesium, Potassium, Titanium, Zinc, Silica and Aluminum which may not have any effect the performance of insulator on dry condition. However on foggy weather conditions, they may pave way to scintillations on the surface of insulators. In case of polymeric insulators, these chemical pollutants may have adverse effects on the surface characteristics. Therefore, it is also recommended to analyze the pollution withstand characteristics of polymeric insulators in online condition over a considerable period of time.

   The effect of increased NSDD content and their non-uniform distribution effects on the surface of insulator have to be analyzed. Such analysis should be carried out by considering profile of insulator and varied T/B (Top to Bottom ratio) NSDD ratio which represent actual field conditions.
3. Interpolation technique (Inverse Distance Weighted) is deployed to create the pollution map for the EASTERN region of India. The maps were generated state wise and the entire EASTERN region. In this methodology the pollution level prevailing in between each site is generated.
4. The soft and hard copies of the pollution map generated by CPRI are attached as a separate file along with this report.

8 References

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Pollution Mapping with Reference to Transmission System - BIHAR

84°0'0"E 85°0'0"E 86°0'0"E 87°0'0"E 88°0'0"E

27°0'0"N 26°0'0"N 25°0'0"N

N E W S

SIKKIM

NEPAL

UTTAR PRADESH

WEST BENGAL

JHARKHAND

BIHAR

BP001 BP002 Pashchim Champaran BP003 BP004 BP005 BP006 BP007 BP007 Purba Champaran Sitamarhi BP014 BP009 BP015 Sheohar BP011 BP012 BP010 Gopalganj BP012 3P012 Madhubani BP024 BP025 BP016 BP026 BP017 Supaul Kishanganj Araria BP028 Siwan 3P020 ER101 FR 02 Muzaffarpur ER103 BP023 Darbhanga ER107 ER108 ER109 Madhepura Saran BP029 BP030 Vaishali BPER119 Samastipur Saharsa Purnia BP031 ER119 BP038 Katihar Khagaria BP034 Begusarai Buxar Bhojpur Patna FR125 ER126 ER127 Bhagalpur BP043 BP041 BPER142 BP042 Munger Nalanda BP047 ER140 Lakhisarai Sheikhpura Jehanabad BP045 BP048 Bhabua Rohtas BPER147 BPER145 BP049 Aurangabad 3P050 BP046 Nawada Gaya BP051 BP052 Jamui Banka

Kilometers

0 10 20 40 60 80 100

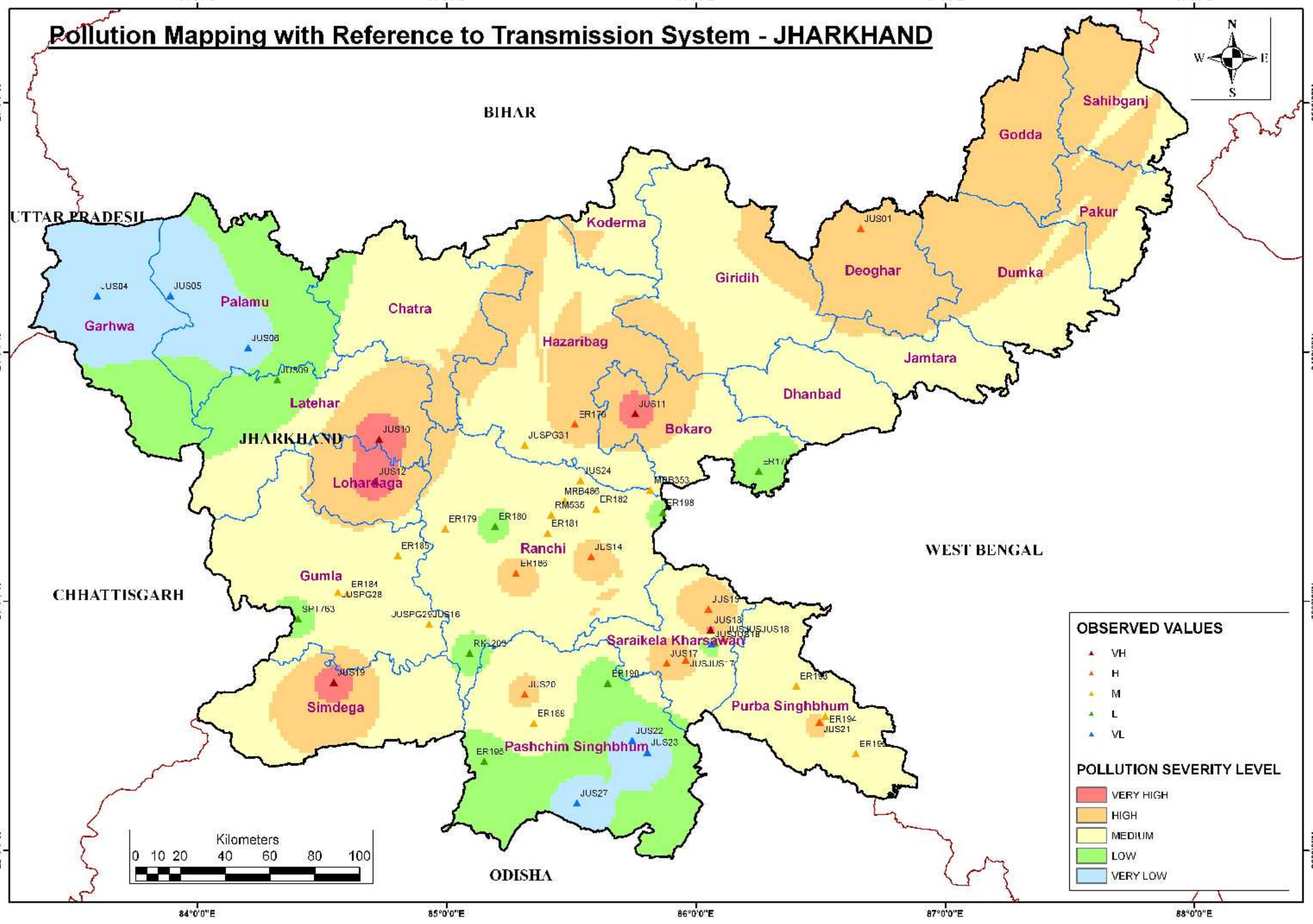
OBSERVED VALUES

- H
- M
- L

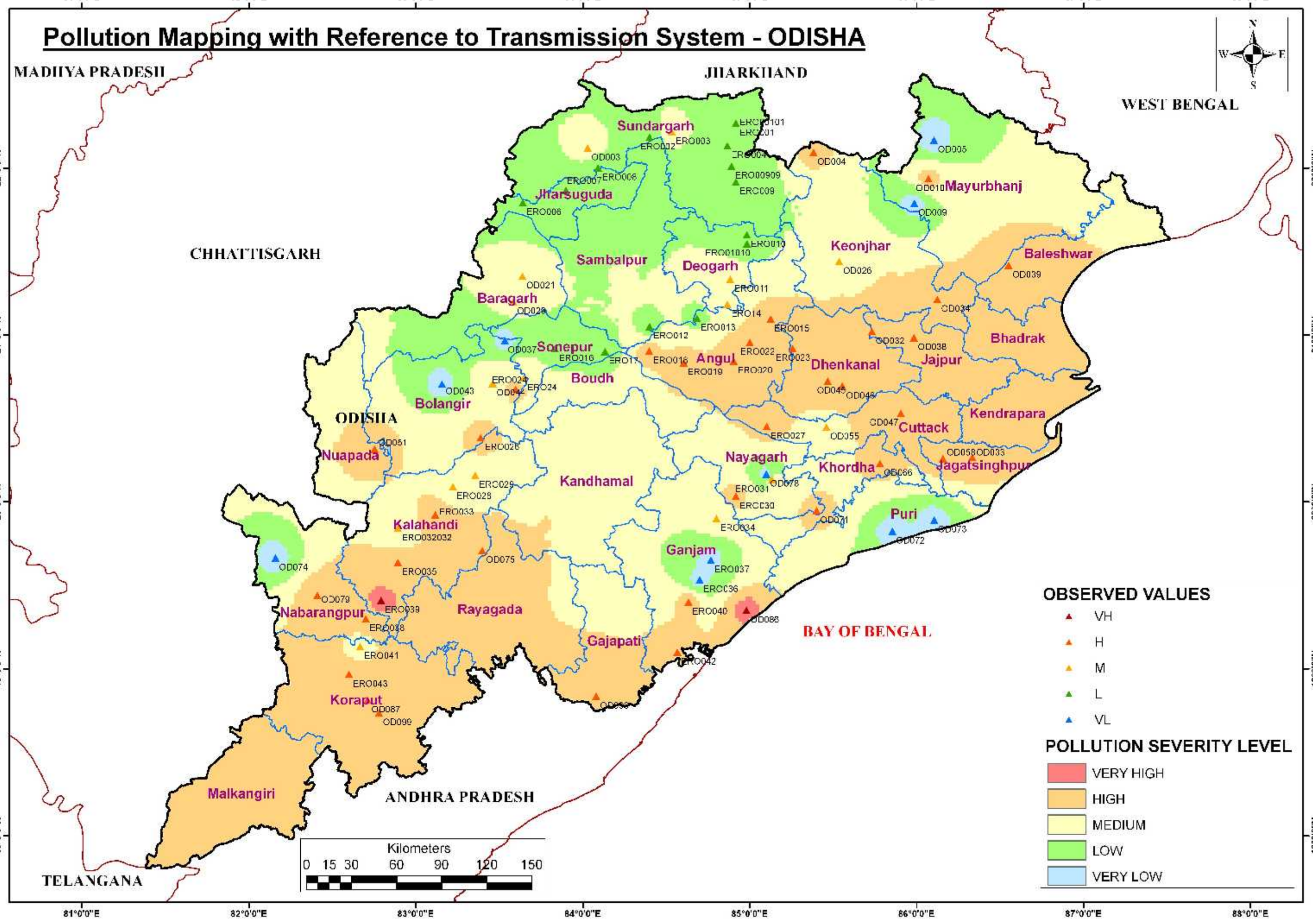
POLLUTION SEVERITY LEVEL

- HIGH
- MEDIUM
- LOW

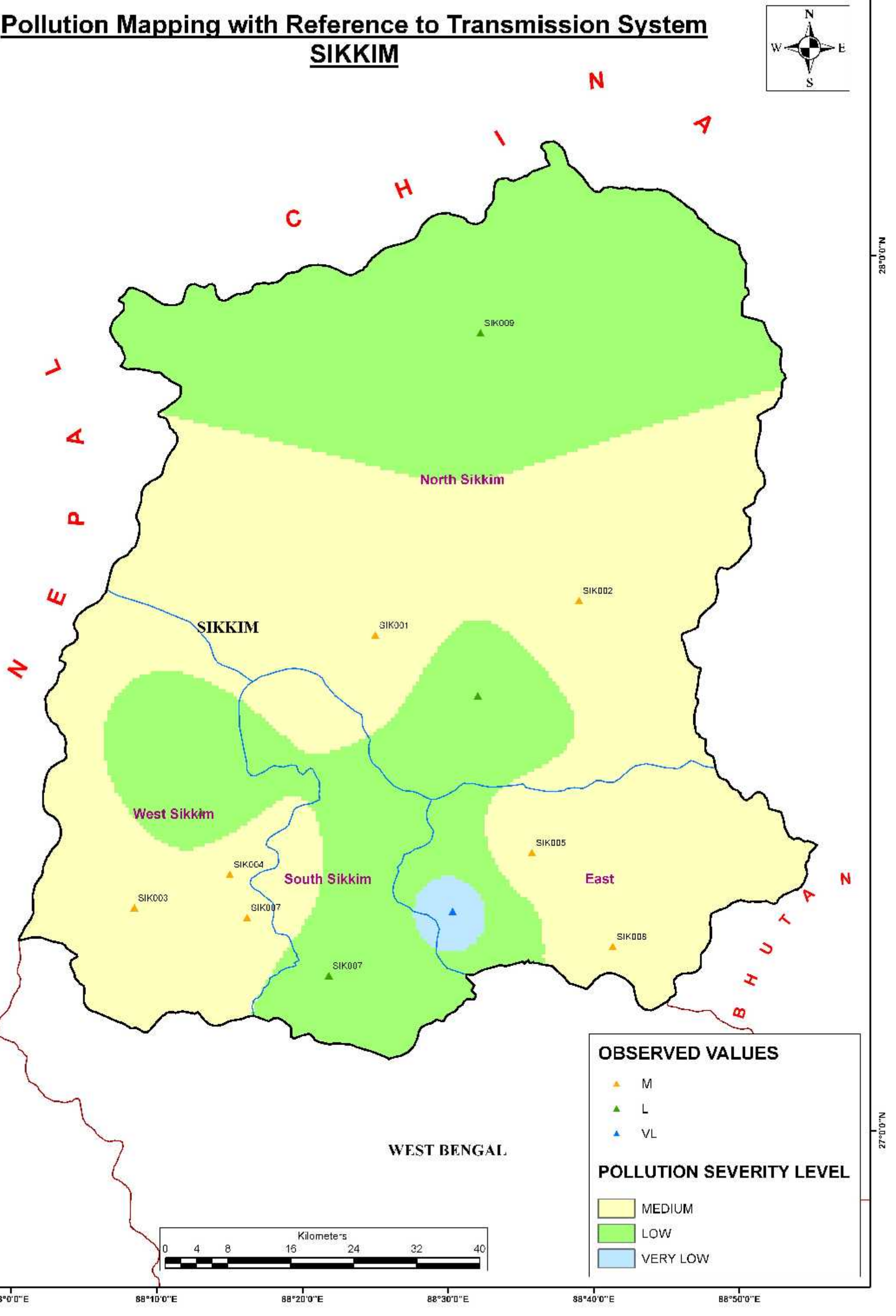
Pollution Mapping with Reference to Transmission System - JHARKHAND



Pollution Mapping with Reference to Transmission System - ODISHA



Pollution Mapping with Reference to Transmission System
SIKKIM



Pollution Mapping with Reference to Transmission System
WEST BENGAL

SIKKIM

BIHAR

JHARKHAND

WEST BENGAL

BANGLADESH

Darjiling
Jalpaiguri
Kochbihar
Uttar Dinajpur
Dakshin Dinajpur
Maldah
Murshidabad
Birbhum
Barddhaman
Nadia
Puruliya
Bankura
Hugli
North 24 Paraganas
Haora
Kolkata
South 24 Paraganas
West Midnapore
East Midnapore

N
W
E
S

86°0'0"E
87°0'0"E
88°0'0"E
89°0'0"E
27°0'0"N
26°0'0"N
25°0'0"N
24°0'0"N
23°0'0"N
22°0'0"N

OBSERVED VALUES

- H
- M
- L
- VL

POLLUTION SEVERITY LEVEL

- HIGH
- MEDIUM
- LOW
- VERY LOW

Kilometers
0 15 30 60 90 120 150