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EFFECTS OF AIR POLLUTION AND INSTALLATION BREAKDOWN OF INSULATORS IN DISTRIBUTION SYSTEM OF PORT HARCOURT

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ABSTRACT

Most power system apparatus are placed outdoor and are often exposed to atmospheric pollution. Due to the existence of different pollutions in the atmosphere, insulating feature of the insulators maybe reduced over time which can result to insulation breakdown and in some cases lead to unexpected outages and damages to expensive equipment of power system (such as transformers, protection relays, and etc). Majority of these pollutions are as a result of human activities in addition to air pollutions and climate change. These impact negatively on the surface of the insulator and cause pollution of insulator surface and other power system equipment. This paper examined effects of air pollution and installation breakdown of insulators in distribution system of Port Harcourt. Different pollution indices (ESDD, NSDD and DDG) were used to estimate the contamination severity for a twelvemonths period. The result of the findings shows that from June 2018 the pollution level was very heavy and gradual decreases to light pollution level at May 2019.

Keywords: Insulator, Distribution line, Air pollution, Conductor, Transformer

INTRODUCTION

Separators are the fundamental hardware of force frameworks and are liable for enduring conductor weight, insulating conductor with respect to the tower, and handling conductor on electric power tower. Due to the existence of different pollutions, insulating feature of the insulators is reduced over time. Some of these pollutions can be removed through washing. In case insulators lose their insulating feature, then it may lead to unexpected outages and damages to expensive equipment of power system (such as transformers, protection relays, and etc). Unexpected power outages bring about economic, political, and cultural problems. Identification of the reasons behind the insulator pollutions will help us to choose the appropriate insulators to be installed in the desired paces, in addition to removing the factors that cause the pollutions. Correct understanding of various types of insulator pollutions would be effective t the time of choosing the proper fluid for washing insulators (Brown and Tayor, 2013).

Solid age and circulation of electrical force is getting an ever increasing number of significant regarding macroeconomics, as universes modern development extends, especially in agricultural countries. (Cherney and Gorur 2014)

Consistency in dispersion and dissemination of force is urgent to proceed with monetary development. Unexpectedly, industrialization prompts expanded degree of natural contamination and air borne foreign substances that can thus trigger breaks in power supply and conveyance brought about by protector based spillage current actuated flashover blackouts. The important dielectric utilized on overhead electrical cables is air at air pressure. The air, encompassing the exposed high voltage aluminum or steel cord aluminum (ACSR) conduits, is a decent protecting material, given that the electric pressure is kept beneath the ionization edge. According to Agoris, et al (2003) noted it is important to join the conductors at specific focuses onto the cross arms of arches the issue of dependably suspending the conductors of high voltage circulation lines has accordingly been with us since the turn of the century. The assignment is especially intricate, remembering the different limit stresses present in mechanical, electrical, natural impact Jacquelyn (2009). According to Abdus et al (2011) High voltage encasings have grown quickly since early this century starting with basic porcelain protectors. Today, modem polymeric separators are utilized, just as early materials. A protector so vigorously dirtied by marine stores that it streaks over promptly on energisation may seem, by all accounts, to be completely perfect, even on close examination. Then again, one which is dark with modern residue, or one with a portion of its surfaces solidified with concrete may have an electrical presentation unclear from that of a newly introduced partner (Arabani, Shirani, &Hojjat, 2017).

I. Statement of problem

Flashover of protectors in transmission and appropriation frameworks may cause expensive blackouts in the substation and their clients. The force organizations are currently confronting expanding rivalry bringing about strain to bring down the expense and to build the framework dependability, because of the impact of air contamination to substation which has prompted:

i. Flashover of high voltage separators brings about the decrease of unwavering quality of force frameworks.
ii. Lost misfortunes to the influence networks because of the impact of the air contamination.
iii. Formation of leakage current.
iv. Decrease of protection in high-voltage transmission lines and substations.

II. Aim of the study

The examination is pointed toward deciding the impact of air contamination in protection breakdown of covers in dispersion framework utilizing non-electrical separator tests techniques.

III. Objective of the study

The objectives of this research work are:

(i) To decide the contamination seriousness of the protector in the influenced appropriation substation.
(ii) To measure the buildup of pollution for the period of 12 months.
(iii) To think about the conduct of different protection materials and protector measurements to the exposed conditions.

MATERIALS AND METHODS

I. Data Collection

The dissemination information were gathered from the Port Harcourt Electricity Distribution Company (PHEDC).

II. Materials Used in the Analysis

i. Porcelainand Composite insulators were used for testing.
ii. Explicit creepage distances at least 30 mm/kV and interfacing lengths was utilized.
iii. Silicone Rubber and EPDM separators having explicit creepage distances of 25 mm/kV.
iv. Insulator Pollution Monitoring Apparatus (IPMA) was used.
v. Test encasings that were utilized included glass plates and porcelain long poles of various explicit creepage distances.
vi. Four vertical assortment containers of Directional Deposit Gauge (DDG) having a ± 370mm x 40mm space processed into each.
vii. 500ml distilled water and 500ml of rainwater was collected in the container.
viii. Huge washbowl and 1litredistilled water to gauge the conductivity of the water.
ix. Surgical gloves were used in order to avoid contamination.

III. Calculation of the DDG Pollution Index

The deliberate volume conductivity should be standardized to a volume of 500 ml and 30 days. The accompanying condition is utilized to ascertain the standardized conductivity:

$$\sigma_n = C \times \left(\frac{V}{500}\right) \times \left(\frac{30}{N}\right) \qquad (1)$$

Where:

σ_n = normalised conductivity ($\mu S/cm$)
C = measured volume conductivity ($\mu S/cm$)
V = volume (ml)
N = number of days

The mean conductivity is acquired by averaging the four standardized conductivities estimated for every one of the breeze bearings. The contamination file is hence characterized as the mean worth of the conductivities. The accompanying condition is utilized to figure the standardized conductivity:

$$\text{Average } \sigma = \frac{(\sigma_N + \sigma_S + \sigma_E + \sigma_W)}{4} \qquad (2)$$

Where:

$\sigma_N, \sigma_S, \sigma_E$ and σ_W are the standardized estimated conductivities for the four principle wind headings.

IV. Calculation of the ESDD Pollution Index

The ESDD is determined by estimating the volume conductivity, temperature of the arrangement, volume of the arrangement and the space of the cover that was cleaned. The volume conductivities should be amended to 20℃.

The accompanying condition is utilized to relate the conductivity:

$$\sigma_{20} = \sigma_\theta \left[1 - 0.02277 \times (\theta - 20) e^{0.01956.(\theta-20)}\right] \qquad (3)$$

Where:

σ_θ = measured volume conductivity at θ°C (S/m)
σ_{20} = volume conductivity corrected to 20 θ°C (S/m)

Brushes, wipes, scrubbers and spatulas can be utilized for the expulsion of obstinate soil however the devices should likewise be remembered for the conductivity test. This is to guarantee that no foreign substances stay behind on the instruments when the conductivity estimation is taken.
The saltiness of the arrangement is dictated by the utilization of the accompanying recipe:

$$S_a = (5.7.\sigma_{20})^{1.03} \quad (4)$$

Where:
S_a= salinity (kg/m^3)
σ_{20} = normalized conductivity (S/m)
The ESDD in mg/cm^2 can then be calculated by the using the following formula:

$$\text{ESDD} = \frac{S_a.V}{A} \quad (5)$$

Where:
V = volume of the solution (cm^3)
A = area of the cleaned surface cm^2

These conditions are substantial when the temperature range is between 5 - 30°C and σ_20 is in the reach 0.004 - 0.4 S/m.

V. Calculation of the NSDD Pollution Index

The NSDD is determined by separating the distinction in loads of the channel paper when the filtration cycle by the space it was taken out from.
The NSDD in mg/cm2 would then be able to be determined by the utilizing the accompanying recipe:

$$\text{NSDD} = \frac{\text{Mass}_2 - \text{Mass}_1}{Area} \quad (6)$$

Where:
Mass_1 = weight of the dry clean filter paper (mg).
Mass_2 = weight of the dry used filter paper (mg).
Area = area of the cleaned surface (cm^2)

RESULT AND DISCUSSION

I. Results of ESDD Measurements

Two distinctive sort of covers porcelain and composite encasings were utilized for this test and the outcomes were additionally acquire porcelain separators with exchanging sheds have been eliminated from existing 132kV pinnacles and dissected for contamination evaluation dependent on ESDD estimations.

II. Calculation of the Specific Creepage Distance

Creepage is the briefest way between two conductive parts estimated along the outside of the protection. A legitimate and sufficient creepage distance ensures against following on the outside of the cover. To determine the required creepage distance for porcelain encasings, distribution IEC 60815 is the principle reference report, wherein four degrees of contamination have been characterized (light, medium, weighty and very heavy)in terms of explicit creepage distance (mm/kV).For a 132kV framework the base creepage distance are given in Table 4.1.

Table 1: Minimum creepage distance of a 132 kV system

Pollution Level(Max. ESDD)	Specific CreepageDistance (mm/kV)	Minimum CreepageDistance (mm)
I. Light(0.06 mg/cm^2)	17	21430
II. Medium(0.2 mg/cm^2)	22	2873
III. Heavy(0.6 mg/cm^2)	27	3762
IV. Very Heavy (> 0.6 mg/cm^2)	33	4639

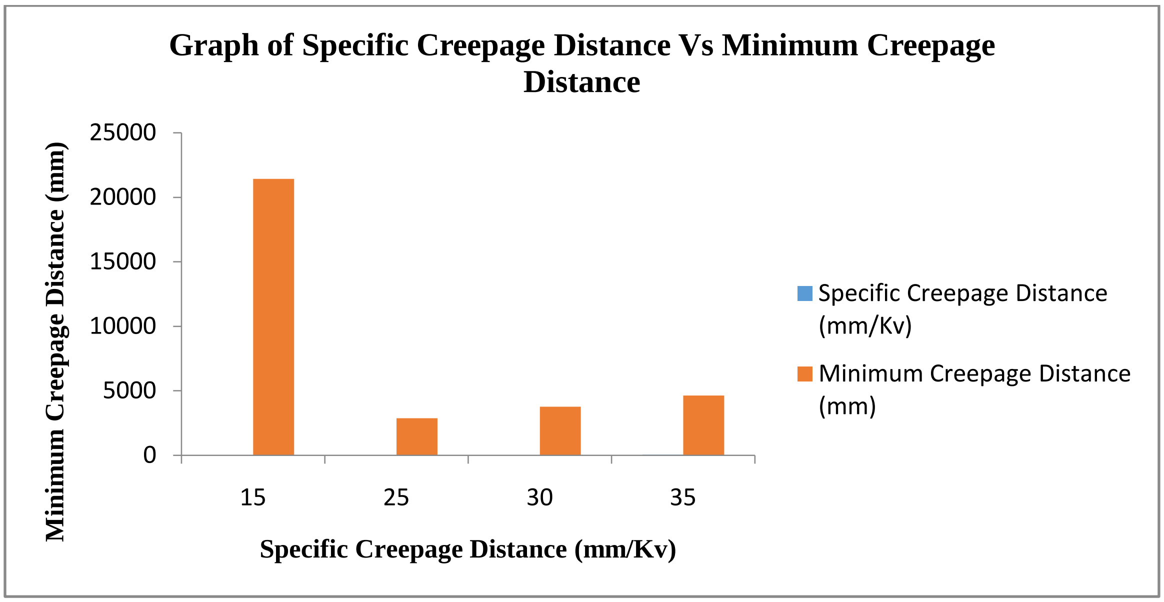

Figure 1: Graph of Specific Creepage Distance and Minimum Creepage Distance

Figure 4.1 show the diagram plot showing the variety of Specific Creepage Distance and Minimum Creepage Distance, from the outcome the specialized determinations of the inspected porcelain and Composite protectors the information sheet demonstrates that both the porcelain and Composite sort covers have a base creepage distance of 21430 mm with a particular creepage distance of 35 mm/kV. This implies that the pre-owned separators are larger than usual since the most extreme contamination level discovered to be in the scope of weighty class. Thusly, it is accepted that the inspected separators can be supplanted with encasings with more modest creepage distance of close to 4639 mm. This will adequately decrease the expense and weight of the separators and exceptionally supportive in surveying the contamination levels during the zones under investigation and in picking the fitting creepage distance of the encasing which assumes a part in lessening contamination flashover of high voltage protectors.

III. Classification of the DDG Pollution Index

After the DDG esteem has been set up, the seriousness can be set up in Table 4.2 show the particular creepage distance needed for every contamination level.

Table 2: Specific Creepage Distance required for each pollution level

Pollution Classification	Minimum Nominal Specific Creepage distance (mm/kV)
Light	16
Medium	20
Heavy	25
Very Heavy	30

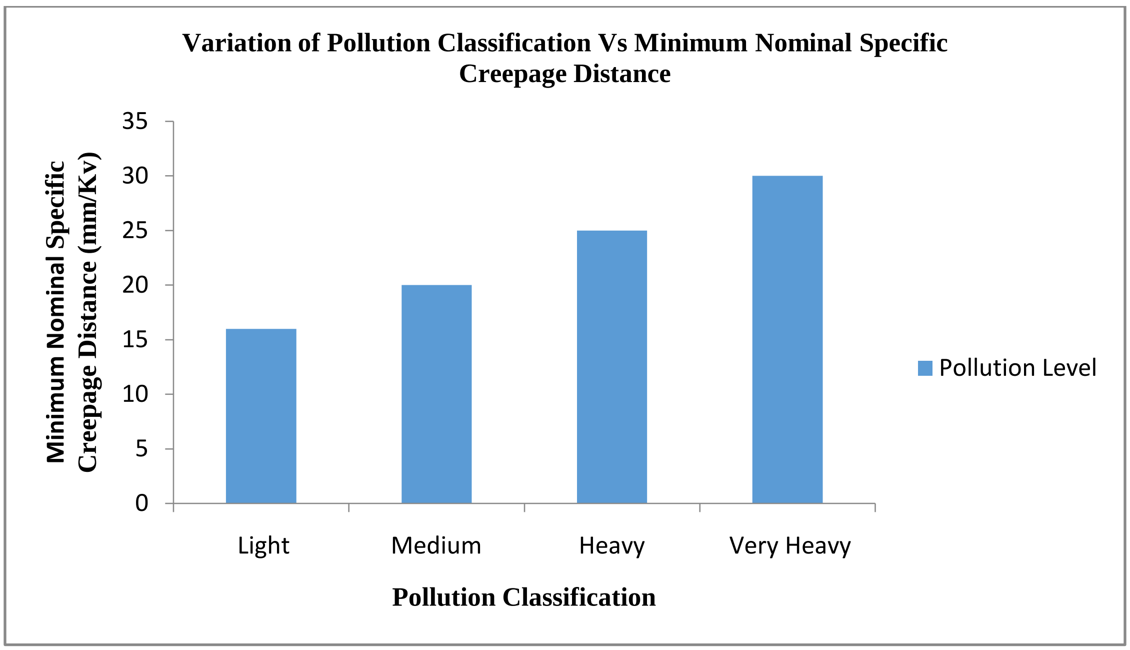

Figure 2: Variation of Pollution Classification and Minimum nominal specific creepage distance

Figure 2 show the bar outline plot showing the variety of Pollution Classification and Minimum ostensible explicit creepage distance, from the outcome the Minimum ostensible explicit creepage distance increments because of the seriousness of the contamination level.

Table 3: ESDD Factor and DDG conductivity

Insulator Exposure Period (months)	ESDD Factor (mg/cm^2)	DDG conductivity µS/cm
June	0.3350	0.0195
July	0.3180	0.0274
August	0.3012	0.0328

September	0.3001	0.0426
October	0.2851	0.0459
November	0.2756	0.0567
December	0.1567	0.0178
January	0.1845	0.0198
February	0.0845	0.0281
March	0.0543	0.0372
April	0.0383	0.0418
May	0.0259	0.0463

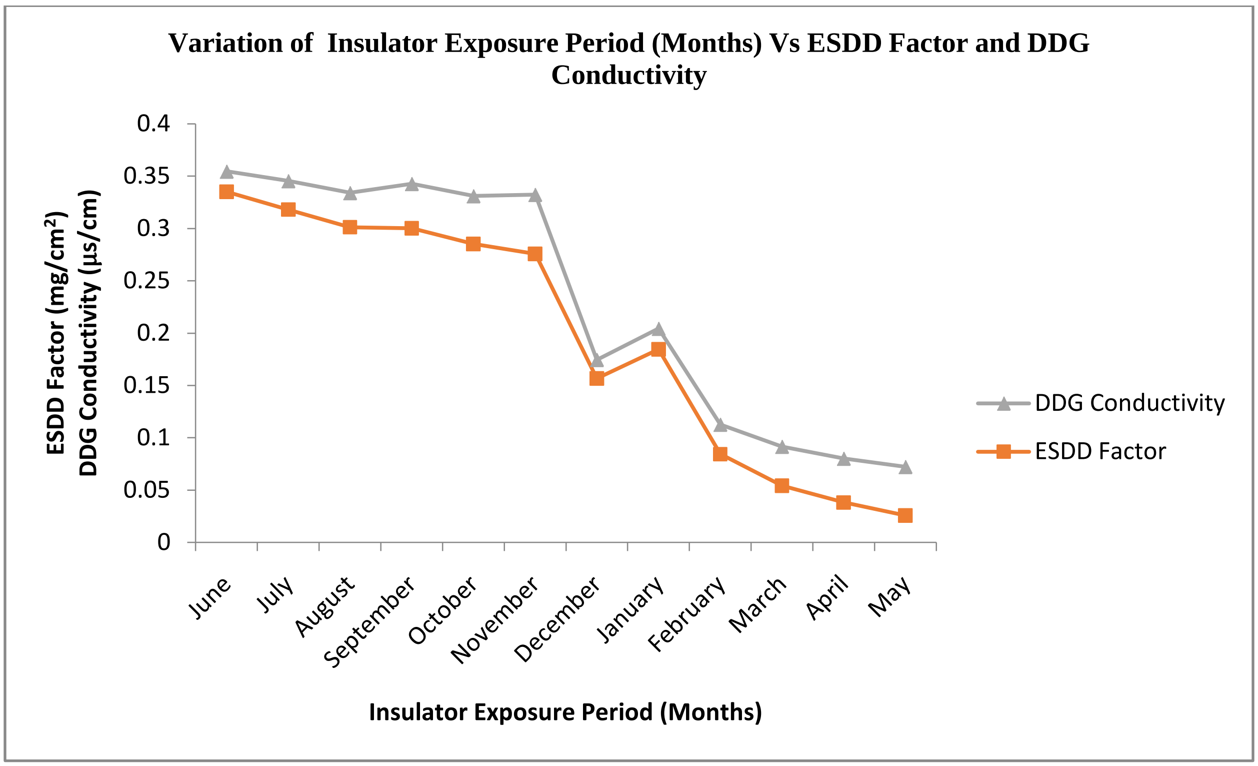

Figure 3: Variation of Insulator Exposure Period (Months) with ESDD Factor and DDG Conductivity

Figure 3 show the graph plot showing the variation of Insulator Exposure Period (From June 2018-May 2019) with ESDD Factor and DDG Conductivity, from the result both the values of ESDD and DDG conductivity varies in respect with the insulator exposure period, precisely from June 2018 the pollution level indicate very heavy Pollution level and gradual decreases to Light pollution level at May 2019.

Table 4: Leakage current value at different severity level

Severity Level	**ESDD (mg/cm^2)**	**Leakage current (mA)**	
		Porcelain	Composite
Very Heavy	0.3350	85.93	50.98
Very Heavy	0.3180	81.47	48.71
Very Heavy	0.3012	80.67	46.45

Very Heavy	0.3001	78.38	43.79
Very Heavy	0.2851	75.62	40.83
Heavy	0.2056	73.90	36.90
Heavy	0.1567	68.73	32.89
Heavy	0.1845	65.36	29.74
Average	0.0845	54.78	26.11
Light	0.0543	51.62	22.79
Light	0.0383	48.45	19.56
Very Light	0.0259	44.72	18.27

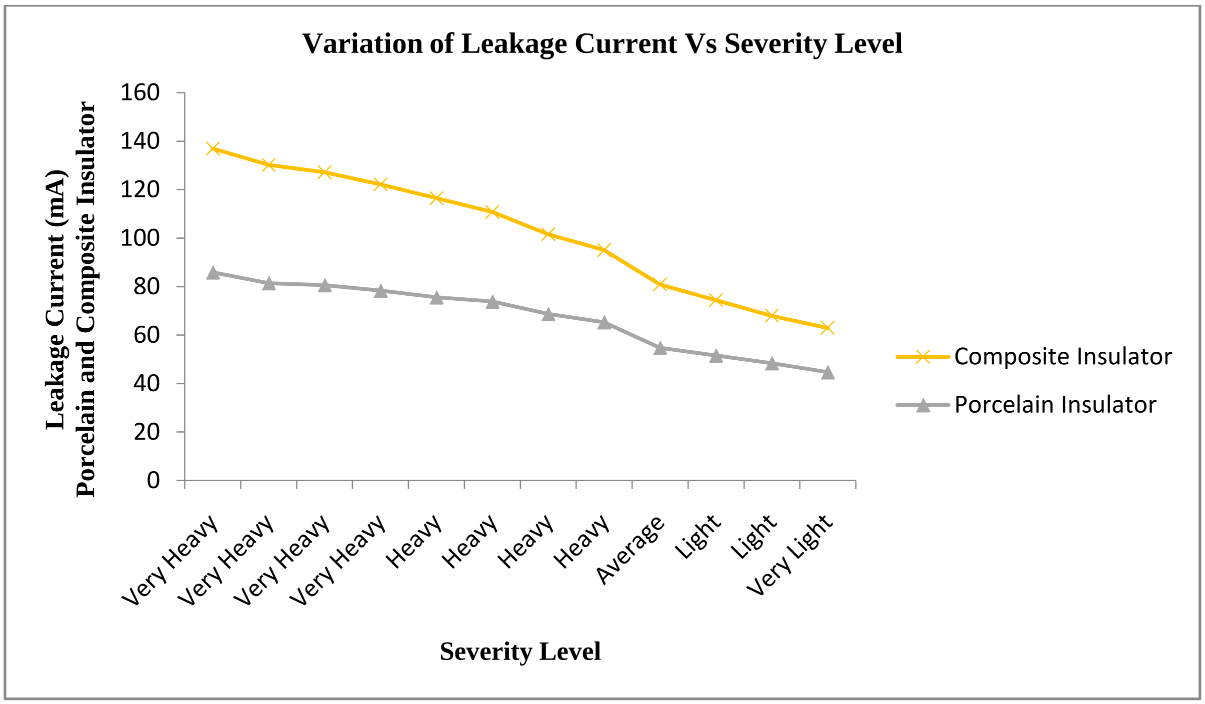

Figure 4: Variation of Leakage Current and Severity level

Figure 4.4 show the graph plot showing the variation of leakage current and Severity level, from the result porcelain and composite insulators were used as case study with respects to severity level, this shows that the effect of pollution in porcelain insulator is less than in composite insulator. Initially the pollution severity level recorded very heavy pollution level and gradually decrease to Very light pollution level.

In table 4.5 the values of insulator exposure period (months) were measured with respects to thewith ESDD and NSDD values from June 2018 to May 2019.

Table 5: Insulator Exposure Period (Months) withESDD and NSDD values

No.	Insulator Exposure Period (months)	ESDD (mg/cm^2)	NSDD (mg/cm^2)
1	June	0.3350	0.0235
2	July	0.3180	0.0461
3	August	0.3012	0.0644

4	September	0.3001	0.0872
5	October	0.2851	0.1098
6	November	0.2756	0.1232
7	December	0.1567	0.1476
8	January	0.1841	0.1609
9	February	0.0845	0.1812
10	March	0.0543	0.2085
11	April	0.0383	0.2247
12	May	0.0259	0.2438

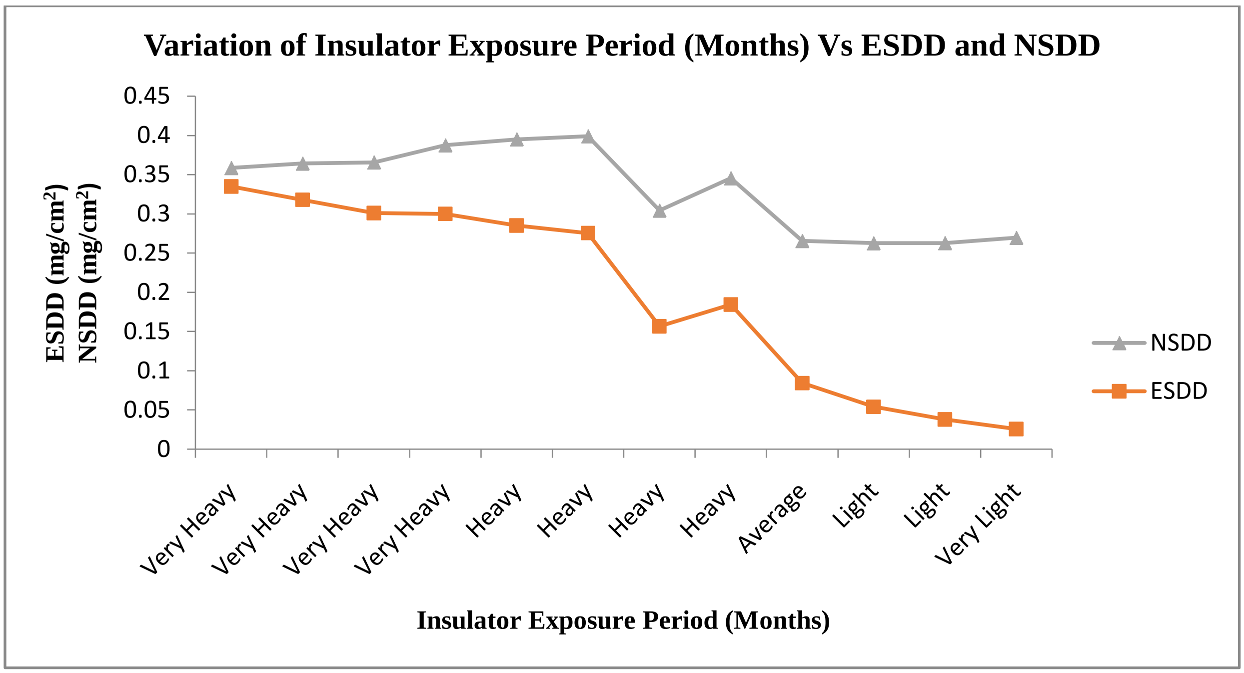

Figure 5: Insulator Exposure Period (Months) withESDD and NSDD values

Figure 5 show the graph plot showing the variation Insulator Exposure Period (Months) in respects with ESDD and NSDD values, from the results the values of ESDD and NSDD indicate Very Heavy pollution level and gradually improved to Very Light which varies from June 2018 - May 2019.

CONCLUSION AND RECOMMENDATION

The examination work analyzed the impact of air contamination in protection breakdown of encasings in appropriation framework utilizing non-electrical separator tests technique. Contamination is a significant factor that impacts the presentation of open air high voltage covers. The term alludes to airborne poisons that, affected by a wetting specialist, may frame a conductive film on the protectors' surface that prompts the beginning of electrical movement that may progress even to a full flashover. The real contamination sway on various covers is the aftereffect of different variables (climate conditions, surface material, and encasings' profile). The contamination estimations (ESDD, NSDD and DDG conductivity) were led for a twelvemonths period. Numerous estimations were led in every stretch to gain more information with the end goal of investigation. Basis on the experimental results and analysis the following recommendations were drawn:

1. Reduction in pollution flashover of the insulators depends on the type of pollution, types of insulators, and their maintenance, therefore better designs of the insulators using best materials arenecessary to improve their contamination performance.
2. The physical location of the place also affects the insulator performance under contamination which varies from place to place, therefore it is recommended to treat the insulators under preventive maintenance using insulator pollution Monitoring Relay (IPMR).
3. The upkeep of dissemination networks is more successful if the protection tainting levels are known, the choice of estimating strategies for contamination levels is then vital.

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