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Efficacy of *Azadirachta indica* Leaf Powder and Ethanol Extract on Adult *Periplanata americana* under Laboratory Condition

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Abstract

The efficacy of *Azadirachta indica* leaf powder and ethanol extract on adult *Periplanata americana* under laboratory condition to control the nuisance of the pest. The mean mortality count of adult *Periplanata americana* was the highest (92) in 50 g leaf powder and the lowest (2) in the control. The result also showed that the highest mortality (125) was recorded in 96 hr exposure time while the lowest (28) was recorded in 24 h exposure time. The Analysis of Variance (ANOVA) for the mean mortality in the experiment and the control indicated that there was significant difference (P-value = 0.05) in the mortality with increase in grams and exposure time of leaf powder and the control at 5% level of significance the mean mortality count of adult *P. americana* was the highest (108) in 50 ml ethanoic extract and the lowest (3) in the control. The result also showed that the highest mortality (144) was recorded in 96 hr exposure time while the lowest (66) was recorded in 24 h exposure time. The Analysis of Variance (ANOVA) for the mean mortality in the experiment and the control indicates that there is significant difference (P-value = 0.05) in the mortality with increase in grams and exposure time of leaf powder and the control at 5% level of significance. The efficacy of *Azadirachta indica* Ethanol extract is more than the leaf powder. There was significant difference in mortality in both increase in concentration levels and exposure time at 5% level of significance in both leaf powder and ethanol extract.

Subject Areas

Plant Science

Keywords

Neem Leaf Powder/Ethanol Extract, Cockroach, Laboratory Condition

1. Introduction

The Neem tree, of the Meliaceae family, is a tropical evergreen plant related to mahogany and found in tropical nations [1] [2] [3]. It originated from South East Asia and is very well known world-wide because of its biological control properties. The name is derived from the Persian word Azadiracta meaning noble tree. Neem is cultivated in many regions of Africa, Australia and Latin America, because it adapts very well to the soil and semi-arid climates in tropical and sub-tropical countries [4]. It shows a good tolerance to dry conditions and soil salinity. Its medicinal properties present a potential for treating animals and humans. The specific use of Neem in India for natural crop potential has extended world-wide over the past number of years, including a great number of countries where it is being sold commercially. The production of insecticides of Neem leaves can be done in a relatively simple, artisanal way or else as an industrial process. Studies indicate that the active substances of Neem (Azadirachtin, Salannin, Nimbin, Nimbidin and Meliantriol) have repellent, antifeedant and insecticidal effects against a number of insect pests [5]. Upon ingestion, they have a very special effect on the metamorphosis of insects, preventing their growth and development. These substances are not toxic to human beings, mammals, birds, reptiles and fishes when applied in the indicated concentrations and do not affect the beneficial flora or fauna in the cultivated fields.

Neem plant measures about 12 - 18 metres in height with a circumference up to 1.8 - 2.4 metres; a flowering plant which produces flower at 3 - 5 years of age [5] of 4 - 7 mm in length and 6 - 10 mm in width [6], having jasmine like odour and white in colour [5]. The leaves are dark green in colour measuring 30 cm in length (Bempah *et al.*, 2011) with 3 lobed stigmata and seeded drupes. The fruit of Neem measures 2 cm long with white kernels and produces 50 kg of fruit yearly when mature [5]. The branch of Neem is dense with up to 10 cm in length and has a dark brown bark [6]. Furthermore, Neem tree adapts to very dry condition [5] [6] of 120˚C with minimal rainfall of 18 inches per year [7]. The plant can grow well in calcareous soil with pH value of 8.5 [8]. Neem tree has attracted worldwide prominence owing to its wide range of medicinal properties.

Azadirachtin is the principal active compound in neem. It is a bitter, complex chemical that is both a feeding deterrent and a growth regulator. Other chemical components of neem include meliantriol, salannin, Nimbin, Nimbidin and other minor components which are also active against insect pests in various ways such as repellents, antifeedants and insecticides. Neem leaf and its constituents have been demonstrated to exhibit immune-modulatory, anti-inflammatory, anti-hyperglycaemic, antiulcer, antimalarial, antifungal, antibacterial, antioxidant, anti-mutagenic and anti-carcinogenic properties. A fraction of Neem oil called Nim-76 was reported to evoke spermicidal activity which makes it suitable for use as pre-coital antifertility formulation for human use, which has undergone phase one clinical trials [9]. Alouani *et al.* [10] in their studies showed that Azadirachtin is useful as larvicidal agent against *Culex pipiens*.

Naturally occurring biopesticide could be an alternative for chemical pesticides. Almost every part of the neem tree has beneficial properties. Water extracts of neem twigs inhibited growth of dental caries organisms *Streptococcus mutans*, *S. salivarius*, *S. mitis*, and *S. sanguis*. Neem extracts have been reported to possess antibacterial, antifungal, antimalarial, and antiviral properties. Neem leaves are used in India for curing diarrhea and cholera. In addition, neem oil and leaves are used in popular medicine as antiparasitic, anti-inflammatory, antiulcer, antihyperglycemic, anticarcinogenic, and immunomodulatory agents [11]. Neem active ingredient azadirachtin, disrupts the metamorphosis of insect larvae and is thus used as a feeding deterrent [12]. Neem supplements and extracts inhibit many bacterial pathogens. Chloroform extracts of neem inhibited the growth of *Listeria monocytogenes* while ethanolic extracts showed higher inhibition for *Staphylococcus aureus.* A water-soluble glycolipid, sulfono quinovosyldiacyl glyceride, isolated from the leaves of neem showed inhibitory activity against *Salmonella typhi*, *Shigella dysenteriae*, *E. coli*, and *Vibrio cholera*. A number of bioactive components have been isolated from various parts of the neem tree. These chemical compounds have different designations, among which azadirachtin (AZ) is the major component.

Neem extract is composed of a complex mixture of molecules, including normal hydrocarbons, phenolic compounds, terpenoids, alkaloids, and glycosides [13]. These molecules act on various phases of an insect's life cycle, making it difficult for pests to resist the physiological effects of neem extract.

The neem plant is very important and of high benefits thus solving many problems. The use of Neem, cannot be overemphasized, it is used basically as drugs, ornament for the treatment of various skin infections such as chronic wound infection, eczema, ringworm, acne, diabetic foot, athlete foot and gas gangrene [14] [15]. It is used worldwide for the treatment of antiviral, antifungal, bacteria, protozoa infection and various diseases. Its parts exhibit wide pharmacological activities such as antioxidant, antimalarial, antimutagenic, anticarcinogenic, anti-inflammatory (its herb produces bitter tonic that reduces inflammation and clears toxins while promoting healing and improving all body function), antihyperglycaemic, antiulcer (its oil is used against stomach ulcers and rheumatism), and antidiabetic properties, antiseptic (its bark contains a strong antiseptic and thus used for soap and toothpaste making, the twigs are used as chewing stick to clean teeth), anticancer agents and detoxifying agent [16] [17]. The neem tree is good for shade and is often planted on road sides as an ornamental plant for beautification of the environment (**Plate 1**).

Another traditional use of *A. indica* has been to chew the *A. indica* sticks. It is still used to clean teeth in rural parts of India. Antimicrobial properties help to reduce plaque and gingivitis. People used *A. indica* twigs as tooth brushes for centuries. *A. indica* twigs contain antiseptic ingredients necessary for dental hygiene and prevents tooth decay, periodontal diseases, infections, bleeding gums and sore gums [18]. *A. indica* oil contains active ingredients that directly deal

Plate 1. *A. indica* tree.

with wound healing in multiple processes. It has a high content of essential fatty acids which is important in its role for adding moisture and a soft texture to the skin during the healing process. The leaf extracts and seed oil of the tree has proven anti-microbial effect. This keeps wound or lesion free from infection by bacteria, viruses, parasites and fungi. Clinical studies have also shown that *A. indica* plays another important role in wound healing by inhibiting inflammation as effectively as cortisone acetate [19]. *A. indica* has shown efficacy in killing cancer cells or boosting the body's immune system to protect it from damage. *A. indica* or its isolated compounds have shown impressive action against a wide variety of human cancer cell that include colon, stomach, lung, liver, skin, oral, prostate and breast. Ethanolic *A. indica* leaf extract was found to induce apoptosis in breast cancer cells in human and as well as animals [11].

With its extremely bitter properties, *A. indica* has been a corner stone of Ayurvedic therapy for pitas, or disorders caused by over eating sweets and in the treatment of diabetes [20]. According to Bansal *et al.* [21], the addition of sodium nimbidinate salt in aqueous form to semen of rat and human resulted in death of sperm in different percentages. Neem oil claimed spermicidal activity against rhesus monkey and human spermatozoa in *in-vitro* condition, and when the oil is used intra vaginally it prevented implantation and pregnancy in rats with concentration of 20 microlitre. In rhesus monkey and women were about 10 mililitre (ml) and the oral dose as low as 25 micro litre, it prevented implantation and does not show any side effects upon repeated application. Similarly, Neem extract (Nim-76) is found to be effective than raw neem oil which act as spermicidal with no alteration in hormonal values. According to Khillare and Srivastava [22], aqueous extract of old and tender leaves show 100% of mortality of the sperms without altering its morphology (head, midpiece and tail).

Neem oil is used to prevent aflatoxin which is produced by *Aspergillus flavus* due to contamination of the poultry feed and the neem leaf extract antagonizes the production of Patulin caused by *Penicillium expansium*. The processed neem

cake poses good appetizer characteristic together with wormicidal activity which is used as poultry feed. Furthermore, neem leaf has significant amount of protein, minerals (except Zinc) and digestible amounts of crude protein and total digestible proteins which served as better nutrition to the poultry animals such as goat, sheep and cow [23]. In a research done by Chandrawathani *et al.* [24]; it was found that neem leaves water extract showed potential reduction in the egg counts of *Haemonchus contortus* a major helminth infecting goats in Malaysia thus proving as antihelminth.

Neem cake residue upon extraction of neem oil from the seed is used as bio-fertilizer for nourishing plants and increasing crop yield [25]. Furthermore, in a research done to elucidate the effects of neem leaves, wood ash and modified neem leaves (Neem leaves + wood ash) on growth of tomato and the effects of extracts on the soil after harvesting the tomato, the research showed that the modified neem leaves highest value of plant height, stem girth, leaf area and number of branches of the tomato plants compared to individual application of neem leaves and wood ash. The poultry manure showed increase in height, stem girth compared to neem leaf extracts. The soil chemical condition were improved by the modified neem leaf extract, which showed the highest value of organic matter, Nitrogen, Phosphorus, Potassium, Calcium and Magnesium in the soil compared to poultry manure and individual application of neem leaves and wood ash [26].

The specific use of Neem in India for natural crop potential has extended world-wide over the past number of years, including a great number of countries where it is being sold commercially. The production of insecticides of Neem leaves can be done in a relatively simple, artisanal way or else as an industrial process. Studies indicate that the active substances of Neem (Azadirachtin, Salannin, Nimbin, Nimbidin and Meliantriol) have repellent, antifeedant and insecticidal effects against a number of insect pests [4]. Upon ingestion, they have a very special effect on the metamorphosis of insects, preventing their growth and development.

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The threat of insects and other pests particularly cockroaches, is well known

and have been a challenge to man. Cockroaches are the most abundant insect pest of public health importance; they infest hospitals, food manufacturing industries, kitchens and residential apartments [27] [28]. Cockroach infestation has always raised safety concerns, especially as carriers of food-borne pathogens and food spoilage organisms [29]. As they feed on materials, cockroaches leave filth and secrete oily liquid having offensive and sickening odour that ruin food [30]. Cockroaches feed on human excreta as well as human food, thus are potential transmitters of diseases such as dysentery, typhoid, cholera and other food-borne infections which have been experimentally confirmed [31] [29] [30]. Dust containing cockroach excreta triggers allergen reaction such as wheezing in many individuals, making it particularly harmful to asthmatic patients [32]. A robust association has been established between the presence of cockroaches and increase in the severity of asthma symptoms in individuals sensitive to cockroach allergen [33] [34].

Cockroaches (**Plate 2**) are the most persistent pest to have colonized the planet. Since their origin, not only do they present a variety of health hazard when found in our houses, but are also a threat in commercial places, spreading diseases through any food source, that they come in contact with [33]. Cockroaches can cause food poisoning by crawling into food materials [34]. Cockroach bite in humans lead to an extremely infested wound, so cockroach infection should be treated immediately. The presence and rising population of cockroach in our homes, especially the kitchen, poses great problems. In spite of so many pesticides used continuously, it seems as these pesticides although kill directly some of it, however cause side effects to humans [33]. Cockroach as pests, pose many health hazards to people. They also cause the destruction of tangible assets and can be damaging to human health too. They damage fabrics, book bindings and foods. This is largely due to the fact that they excrete only liquid which is not

Plate 2. The American cockroach; *Periplaneta americana*.

only dirty and filthy but carries an odor which is offensive to the nose, and can contaminate food substances [33]. Cockroach control is carried out using pesticides in form of chemical or gels, however, these alone are not 100% effective against the pest menace as the chemicals are directly or indirectly toxic, therefore an integrated pest management program is required.

The ancient man had deployed different methods of control, including prayers, magic spells, cultivation systems, mechanical practices as well as application of organic and inorganic substances [35]. Between 500 BC and the 19th century a number of substances which were classified as pesticides and defined as" any substances or mixture of substances for preventing, destroying, repelling or mitigating any pest" were used to control pests. The best pest control method is that which is non-toxic and environment friendly, hence the use of natural plant parts as bio-pesticides. To overcome the problems of synthetic chemical hazards, the use of plant origin product is considered the best control measure which has become popular due to their degradability, least persistence and least toxicity to non-target organisms, economical and easy availability. About 200 plants with insecticidal activities are known including *Azadirachta indica* (neem) tree whose insecticidal properties have proven successful in the control of over 550 insect species such as the orders Dictyoptera (cockroaches and mantis), Coleopera, Isoptera, Homoptera, Heteroptera, Diptera Orthoptera and others [4].

Developing countries and Nigeria in particular face the most challenges in achieving the sound management of pesticides. A large proportion of the population in Nigeria is directly engaged in agricultural work, often on a very small scale. While evidences abound that botanical pesticides are generally safe and effective [36]. Their use in Nigeria as in other parts of Africa is still hampered by some challenges such as most data on botanical pesticides been obtained from laboratory trials; field data are rare. There is still hardly any developed appropriate technology for the application of botanicals, especially the oil and dust formulations [37]. Also compared with synthetic insecticides, the effects of natural insecticides are short-lived thus frequent applications are required to obtain reasonable degree of crop protection? Furthermore, bio pesticides formulations are yet to be available in usable forms to farmers in commercial quantities so as to serve as alternatives to synthetic pesticides.

From the foregoing, the need to advocate for and implement integrated pest management strategies both on field pests, storage product pests, structural pests and domestic pests is indispensable. Therefore the discovery advocating for the adoption and promotion of the use of bio pesticides like neem plant (*A. indica)* in an integrated pest management frame work is quite relevant. There has been evident shift all over the world from synthetic pesticides to non-synthetic ones; largely due to the wide spread awareness of the side effects of these synthetic pesticides on plants, soil and other living organisms. Plant extracts have been used worldwide as an alternative method to control pests unlike synthetic pesticide. Single plant derived compound may have more than one biological effect

[38]. There is therefore the need know more about the biopesticidal effects of neem plant.

2. Materials and Methods

Fresh leaves of *Azadirachta indica* were collected form Amassoma Town in Southern Ijaw Local Government Area, Bayelsa State, Nigeria. They were identified at the herbarium of the University of Port Harcourt, Rivers State, Nigeria. The leaves of *Azadirachta indica* were separated manually. The plant leaves were oven dried under the temperature of 60˚C overnight [39]. The dried leaves were ground into powder using electric blender (Binatone model) and sieved to obtain fine powders. The plant powders were put in air tight containers separately to ensure that the active ingredients are not lost. The powders were stored in a cool dry place until when needed.

For the extract, 1.5 kg of the powder was mixed with 2.8 liters of Ethanol and the mixture was allowed to stand overnight in the refrigerator. The following morning, this mixture was blended and filtered. The filtrate was evaporated using a desiccator and the resultant yield was 60 g of the extract which was about 4% yield. This was preserved in the refrigerator at 40c until ready for use. The total of Two hundred and forty (240) adult American cockroach used for the experiment were reared in a plastic container under ambient laboratory temperature of 30˚C ± 3˚C and 75% ± 3%. *P. americana* was fed with bread crumbs. One hundred *P. americana* were introduced into each treatment. All Treatments were arranged in completely randomized design (C.R.D).

Data Collection and Statistical Analysis Data were generated and recorded from mortality count of adult *P americana* at 24, 48, 72, 96 hrs and were used to determine the most efficient proportions of the powders. Dead weevils were removed and discarded after every count. Data generated on mortality of the weevils due to efficacy of leaf powders were subjected to analysis of variance (ANOVA) using SPSS computer Software package (version 20) at 0.05 significant levels.

3. Results

The mean mortality of adult *Periplanata americana* exposed to *Azadirachta indica* leaf powder is presented in **Table 1**. The result showed that the mean mortality count of adult *Periplanata americana* was highest (92) in 50 g leaf powder and lowest (2) in the control. The result also showed that the highest mortality (125) was recorded in 96 hr exposure time while the lowest (28) was recorded in 24 h exposure time. The Analysis of Variance (ANOVA) for the mean mortality in the experiment and the control indicated that there was significant difference (P-value = 0.05) in the mortality with increase in grams and exposure time of leaf powder and the control at 5% level of significance (**Table 2**).

The mean mortality of adult *P. americana* exposed to *Azadirachta indica* ethanoic extract is presented in **Table 3**. The result showed that the mean mor-

tality count of adult *P. americana* was highest (108) in 50 ml ethanoic extract and lowest (3) in the control. The result also showed that the highest mortality (144) was recorded in 96 hr exposure time while the lowest (66) was recorded in 24h exposure time. The Analysis of Variance (ANOVA) for the mean mortality in the experiment and the control indicates that there is significant difference (P-value = 0.05) in the mortality with increase in grams and exposure time of leaf powder and the control at 5% level of significance (Table 4). The result Table 1 and Table 3 showed that the efficacy of *Azadirachta indica* Ethanol extract is more than the leaf powder. There was significant difference in mortality in both increase in concentration levels and exposure time at 5% level of significance in both leaf powder and ethanol extract.

Table 1. Mean mortality of adult Periplanata. americana exposed to azadirachta indica leaf powder.

Leaf Powder Quantity (g)	Exposure Time (Hrs)					
	24	48	72	96	**TOTAL**	**MN ± S.E**
00	0	0	1	1	**2**	**0.5 ± 0.3**
10	0	5	13	18	**36**	**9.0 ± 4.0**
20	2	13	17	22	**54**	**13.5 ± 4.3**
30	5	15	21	26	**67**	**16.8 ± 4.5**
40	9	17	25	28	**79**	**19.8 ± 4.3**
50	12	22	28	30	**92**	**23.0 ± 4.0**
TOTAL	28	72	105	125	**330**	
MN ± S.E	**4.67 ± 2.03**	**12.0 ± 3.31**	**17.5 ± 3.96**	**20.8 ± 4.34**		

Table 2. Analysis of mortality rate in adult P. americana exposed to azadirachta indica leaf powder.

Descriptive statistics					ANOVA					
Groups	Sample size	Sum	Mean	Variance	Source of Variation	d.f.	SS	MS	F	p-value
24 Hr	6	28.	4.67	24.67	Between Groups	3	898.83	299.61	4.03	0.02
48 Hr	6	72.	12.	65.6	Within Groups	20	1487.67	74.38		
76 Hr	6	105.	17.5	94.3	Total	23	2386.5			
92 Hr	6	125.	20.83	112.97	Residual standard error	8.62				
Total	24		15.46	111.48	Hartley Fmax (d.f. = 4, 5)	4.58				
					Cochran C (d.f. = 4, 5)	0.38				
					Bartlett Chi-square (d.f. = 3)	2.65				

Table 3. Mean mortality of adult Periplanata. americana exposed to azadirachta indica ethanoic leaf extract (ml).

Ethanoic Leaf Extract (ml)	Exposure Time (Hrs)					
	24	48	72	96	**TOTAL**	**MN ± S.E**
00	0	1	1	1	**3**	**0.8 ± 0.3**
10	7	12	19	25	**63**	**15.3 ± 3.9**
20	9	15	20	28	**72**	**18.0 ± 4.0**
30	12	23	27	30	**92**	**23.0 ± 3.9**
40	18	25	29	30	**102**	**24.8 ± 3.4**
50	20	28	30	30	**108**	**26.8 ± 2.6**
TOTAL	66	104	126	144	**440**	
MN ± S.E	**10.3 ± 2.7**	**17.3 ± 4.1**	**21.0 ± 4.4**	**24.0 ± 4.7**		

Table 4. Analysis of mortality rate in adult P. americana exposed to azadirachta indica leaf extract (ml).

Descriptive statistics					ANOVA					
Groups	*Sample size*	*Sum*	*Mean*	*Variance*	*Source of Variation*	*d.f.*	*SS*	*MS*	*F*	*p-value*
24 *Hr*	6	63.	10.5	47.5	*Between Groups*	3	629.79	209.93	2.12	0.13
48 *Hr*	6	106.	17.67	99.87	*Within Groups*	20	1982.17	99.11		
76 *Hr*	6	130.	21.67	118.27	*Total*	23	2611.96			
92 *Hr*	6	144.	24.	130.8	*Residual standard error*	9.96				
Total	24		18.46	113.56	*Hartley Fmax* (*d.f.* = 4, 5)	2.75				
					Cochran C (*d.f.* = 4, 5)	0.33				
					Bartlett Chi-square (*d.f.* = 3)	1.26				

4. Discussion

Result of the present study showed that the mortality of *P. americana* exposed to *A. indica* leaf powder increased with increase in grams and exposure time. Similarly, the mortality of *P. americana* exposed to *A. indica* ethanoic extract also increased with increase in concentration levels and exposure time. The result compared favourably with results from similar studies. Akunne *et al.* [40]; reported that *A indica* when mixed separately with stored cowpea seeds as pest control agents caused the mortality of adult *C. maculatus* compared to the control (4.00 ± 1.41; 2.67 ± 1.41; 1.89 ± 1.17). Raguraman and Singh [41]; Musa *et al.* [42] and Moses and Dorathy, [43] also carried out study on *A. indica* and reported that *A indica* is a potential botanical pesticides.

Raguraman and Singh [41] reported that neem tree has long been recognized for its pesticidal properties against insect pests. Moses and Dorathy [43] reported that bitter leaf gave the best protection against cowpea weevil when compared with garlic and ginger. They also reported that the significant difference ($P < 0.05$) obtained in the mortality of *C. maculatus* by comparing the efficacy of *A. indica* leaf powder with the control is an indication that *A. indica* leaf powder has some insecticide properties capable of controlling pests of stored

cowpea. Girish and Shankarah, [44] also reported that neem tops the list of 2400 plant species that are reported to have pesticide properties and is regarded as the most reliable source of eco-friendly biopesticide properties.

Brisibe *et al.* [45] reported that, of the three botanical pesticides (*A. annua*; *A. indica* and *O. gratissimum*) tested, the highest adult insect mortality rate was recorded in the treatment with the highest concentration (20 g/250g cowpea seeds) of dried and pulverized leaves respectively. They reported that at the concentration of 5 g of the tested botanicals, no significant difference existed among them but in the present study, the treatment with the highest concentration of 5 g of the leaf powders of *A. indica* on 30 g of cowpea seeds caused a significant difference in the mortality of *C. maculatus*. They also reported that the leaf powders of the two plant species can serve as botanical pesticides with *A. indica* leaf powder showing more efficacy than the *V. amygdalina* leaf powder. They further reported that moderate mean mortality count of adult *C. maculatus* was obtained from the cowpea seeds mixed with leaf powders of neem and bitter leaf at equal proportions.

Ofuya *et al.* [46] who reported that adult mortality of *C. maculatus* was found to increase with increase in concentration levels of bioinsecticide leaf powders. It is worthy to note that the concentration of bioinsecticides is a factor to be considered in the control of adult *P americana*.

Mondal and Mondal [4], in their studies revealed that natural pesticides are eco-friendly, safe and least toxic, least persistent, economical easily available and are thus used extensively in the agricultural fields and store to control crop pests. They stated that Azadiractin an active compound extracted from *A. indica,* have insecticidal properties used in the control of nearly 550 insect pest species. Studies revealed that nearly 400 insect species across various insect orders in addition to arachnids and nematodes have been controlled using *A. indica* extracts [47].

A. indica pesticides play a vital role in pest management and hence have been widely used in Agriculture for its safety and efficacy as bio pesticides [38]. There has been evident shift all over the world from synthetic pesticides to non-synthetic ones; largely due to the wide spread awareness of the side effects of these synthetic pesticides on plants, soil and other livings organisms. Neem oil is a naturally occurring pesticide found in seeds from the neem tree. It is yellow to brown, has a bitter taste, and a garlic/sulfur smell. It has been used for hundreds of years to control pests and diseases. The biologically active compound azadirachtin (extract of *A. indica* seed), act as repellent for a broad spectrum of agricultural and household insects. This plant is traditionally used as pesticidal agent in India [48].

Azadirachtin reduces insect feeding and acts as a repellent. It also interferes with insect hormone systems, making it harder for insects to grow and lay eggs. Neem oil is reportedly used to control the following pests: garden snails and slugs, cockroaches, bed bugs, scabies, dust mites, ants, fleas, ticks, fruit fly, whiteflies, Japanese beetles, cherry slug, pear slug [49]. Apart from these uses, neem

products are being marketed world over by many companies, such as neem soaps, shampoo, toothpaste, hand and body lotions, face wash, food supplements, agricultural products and veterinary products. Agroneem is a formulation containing azadirachtin (0.15%) as the active ingredient, 15% neem biomass (neem lipids), thus utilizing the complete spectrum of neem's potential as a pest management tool [48]. It attacks insects at different stages of growth as anti-feedant, insect repellent, growth regulator and insecticide. It is non-toxic and does not harm the workers. It is bio-degradable and protects the environment. It is compatible with most commonly used fertilizers, fungicides and insecticides. In a research by Musabyimana *et al.* [50], the wetting of banana corm or pseudo-stem with neem cake extract, aqueous neem seed powder, neem kernel powder or with emulsified neem oil distrupted the settling response, egg laying, and larval feeding of *Cosmopolites sordidus* (Banana Corn Borer) [50].

Extracts from the neem tree are also used as repellents (the wood of the neem tree is strong and resistant to termite damage, used as mosquito repellents and as firewood for charcoal making), fumigant, pesticides (the leaves act as a natural pesticide), fertilizers, manure (neem leaves and the cakes gotten when oil has been removed from seeds can improve soil structure and add to the plant nutrient base), diabetic food and animal feed, urea coating agent and soil conditioner (neem leaves can be used to make soil less acidic) [51]. Castillo *et al.* [52] reported that the toxic effect of *A. indica* is ephemeral in nature disappearing within 14 - 21 days. They also investigated the successful use of *A. indica* in the control of migration locust, army worms, whitefly and even head lice and also that it is found to be safe to beneficial organism such as earthworms. (Prakash and Rao, [53] stated that powdered seed kernel of *A. indica* mixed with harvested rice significantly reduced insect pest infestation. Also mixing *A. indica* leaves with harvested rice, treating storage bugs with *A. indica* extract or putting its leaves between the bags and storage floor achieved similar results.

Plant extracts have been used worldwide as an alternative method to control pests unlike synthetic pesticide which have one active compound, and exhibit only one type of biological effect. Single plant derived compound may have more than one biological effect [38]. Detailed investigations have revealed that several plants species have more than one compound and have diverse biological effects. The chances of quick development of resistance to different chemical is minimal in extracts responsible for biological effect or repelling of some natural plant as with the neem plant (*A. indica*). This plant is herbal plant, including its effect against insect pests. Various parts of the neem tree, (bark, leaves, flowers, seeds and fruits pulp) are used mostly in the powder or extract form. Neem has medicinal and pesticide properties resulting from its various active components, including Azadiractin which is the main ingredient used in the manufacture of biopesticides. *A. indica* pesticides are being manufactured and exported to various countries as lots of research are been conducted to test its safety and efficacy for use as pesticides [54]. *A. indica* oil and seed extracts are known to possess germicidal and anti-bacterial properties which are useful to protect the plants

from different pests. The greatest advantage of *A. indica* based pesticides and insecticides are that they do not leave any residue on the plants.

Laboratory experiments were conducted to study the insecticidal properties of Neem extract. Powders, liquid prepared from various neem parts (seed, leaf, stem, and root) against the *macrotermes species phaseolus*, Periplaneta specie and larvae of Anopheles species which are important pests of agriculture and public health [55]. The lethal effect was more pronounced with the seed extract (40% - 55%), followed by the leaf extract (30% - 45%), the stem extract (30% - 40%) and root extract (10% - 30%) as compared to the control which registered 0% mortality Achio *et al.* [56]. The termite and the Weevil were more susceptible to the extracted oil with minimal lethal concentration. Also, the termites and the weevil responded faster recording total death within 2 - 5 minutes, compared to the cockroaches and the mosquito larva, where total death was experienced only after 30 - 90 minutes. It was also found out that there was a direct relation between the concentration and degree of lethal effectiveness of the oil, and leaf. The neem seed oil had great potential as natural biocide against cockroaches, termites and weevils [57].

5. Conclusion

A. indica leaf powder and ethanol extract are very effective in the control of *Periplanata americana* and other insect pests. The ethanol extract is however more effective than the leaf powder and should be recommended for controlling the menace of American coachroach since it is void of adverse environmental pollution. To solve the menace of cockroaches, effort should be geared towards applying *A. indica* leaf powder or its ethanoic extract to safeguard the adverse effects of conventional pesticides. Furthermore, *A. indica* is cheap and readily available. However, further research is required to determine the efficacy of the neem using higher concentrations and on a wide range of other common insect pests.

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