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Posterior Lenticonus

Anubhav Chauhan* and Deepak Kumar Sharma

1. Dept. of Ophthalmology, Shri Lal Bahadur Shastri Government Medical College and Hospital, Nerchowk, Distt. Mandi, Himachal Pradesh, India

*(ORCID: 0000-0002-1122-2202)

OPHTHALMIC IMAGES

A 15-year-old male, reported to us with a history of painless, progressive diminution of vision in his left eye for the past few years. There was no other significant history. His best corrected visual acuity was 6/18 in his left eye and 6/6 in the right eye. Colour vision, intraocular pressure, fundus, B scan and ocular movements were within normal limits. Slit lamp examination revealed a posterior lenticonus (figure 1) in his left eye with early cataractous changes. His systemic workup was normal. He has been planned for cataract extraction with posterior chamber intraocular implantation, but the possibility of amblyopia in the left eye was explained to the patient and his parents in detail.

Posterior lenticonus is a localized bulging of the lens cortex and posterior capsule. It occurs in approximately 1–4 of every 100,000 children and is predominantly unilateral.[1] The bulging is due to thinning of the posterior capsule.[2] This disease is often associated with Duane retraction syndrome, microphthalmos, keratoconus, ocular colobomas, anterior chamber angle anomalies, anterior lenticonus, persistent hyaloid artery remnants, axial myopia, Alport and Lowe syndrome.[3] Oil drop sign and fish tail sign are described in posterior lenticonus.[4] Treatment consists of clear or cataractous lens extraction, optical correction along with amblyopia therapy.[5]

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Conflicts of Interest

The authors declare that they have no competing interest.

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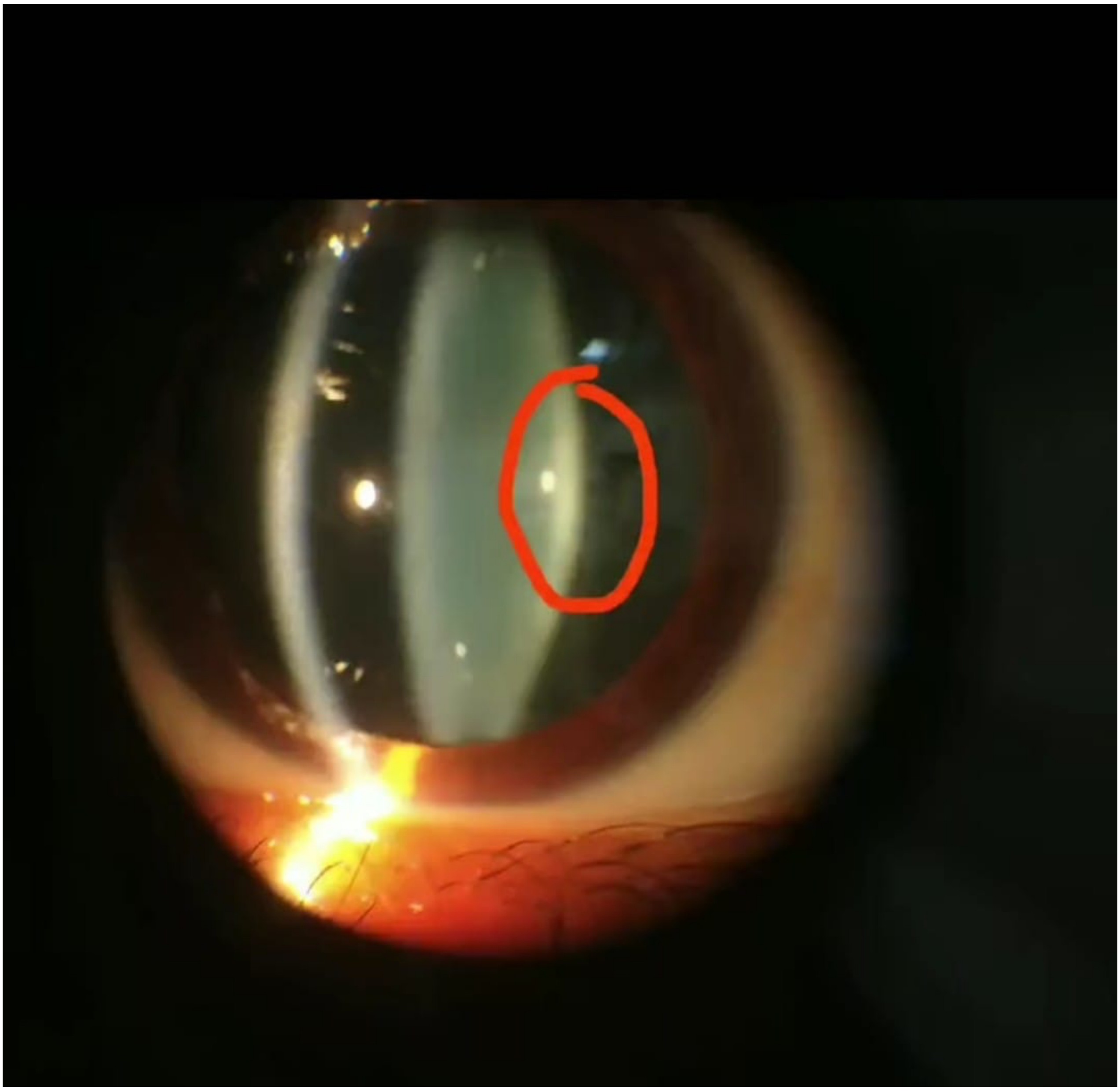

Figure 1.

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Medical desertification and National Recovery and Resilience Plan in Italy: Focus on Inner Areas

Mariano Votta, Maria Vitale, Bianca Ferraiolo, and Maria Eugenia Morreale

Abstract:
The shortage of doctors and nurses runs through all of Italy, but in peripheral inner areas it takes on the contours of "medical desertification." To what extent does the National Recovery and Resilience Plan (NRRP), in providing for Community Homes (CHs) and Community Hospitals (HHs), along with ad hoc funds for health personnel [1], respond to this critical issue? What are the prospects for inner areas? The risk is that the problem will not be solved by the funds made available by the NRRP; in fact, only 16-17% of Community Homes and Hospitals will be built in these areas. This means that the future of peripheral and ultraperipheral inner areas in Italy is at stake. The detailed analysis, conducted in Italy by Cittadinanzattiva, is part of the European project AHEAD [2], "Action for Health and Equity: Addressing Medical Deserts," funded by the EU4Health program to find solutions to these " medical deserts."

Keywords: Medical desertification, NRRP- National Recovery and Resilience Plan, access to care, patients' rights, civic participation, "AHEAD-Action for Health and Equity: Addressing Medical Deserts", EU4Health, Inner Areas, health inequalities.

INTRODUCTION

The Inner Areas, despite being characterized and tried by demographic weakening and the lack of multiple services, especially in the areas of education, health and mobility, constitute a peculiar and vibrant part of our country. In fact, they represent about 53% of Italian municipalities (4261), are home to 23% of the Italian population, i.e., more than 13.54 million inhabitants, and occupy a portion of territory that exceeds 60% of the national surface [3].

The "National Strategy for Inner Areas" (NSIA) has had the merit of putting the issue of inner areas on the political agenda and addressing, with method and vision, the interventions affecting them [4].

Limited to the health needs of communities living in inner areas, there is no doubt that over the years the health issue has been one of the historical dividing factors of these areas (to the point that distance from health centers constitutes an index of peripherality for the purposes of the NSIA). Thus, it can be affirmed that the implementation of the National Recovery and Resilience Plan (NRRP) will be a key test case for improving life in the inner areas. Even without bringing up telemedicine, which requires, in order to provide an effective service, an adequate digital culture of the target population (these areas are mainly populated by the elderly), the most promising interventions are those concerning the reform of territorial medical care, where the Community Houses envisaged by "DM 77"-to which, among other things, Cittadinanzattiva has devoted much attention by putting forward proposals [5] and engaging in an initial civic mapping on the state of progress of the aforementioned Houses - could actually make a difference for territorial medicine, which has been reduced to the brink by years of health policies aimed at merging every health facility into large hospital hubs [6].

METHODOLOGY

The analysis conducted by Cittadinanzattiva-using official data provided by the Ministry of Health for 2020 and ISTAT for 2022-has identified, as the first stage of the research, 39 provinces and 9 regions where the imbalances, between the number of professionals and citizens, are most pronounced: Lombardy (Bergamo, Brescia, Como, Lecco, Lodi, Milan) and Piedmont (Alessandria, Asti, Cuneo, Novara, Turin, Vercelli) lead with six provinces, followed by Friuli Venezia Giulia (Gorizia, Pordenone, Udine, Trieste) and Calabria (Cosenza, Crotone, Reggio Calabria, Vibo Valentia) with four provinces. They are followed by Veneto (Treviso, Venice, Verona), Liguria (Imperia, La Spezia, Savona) and Emilia Romagna (Parma, Piacenza, Reggio Emilia) with three provinces each, Trentino Alto Adige (both the autonomous provinces of Bolzano and Trento) and Lazio (Latina and Viterbo) with two provinces.

The second phase of the research - described in detail in the pertinent report - brings together the characteristics of the municipalities and the detailed analysis of the actions planned on the territory under Mission 6 Health - Component C1 of the NRRP: proximity networks, facilities and telemedicine for territorial health care (all of which were merged into the Operational Plans of the CIS/Institutional Development Contracts [7] for the execution and implementation of direct investments, signed by the Regions and Autonomous Provinces with the Ministry of Health in May 2022). In this regard, it is necessary to keep in mind that Italian municipalities are classified by distinguishing centers and inner areas. Centers are classified as follows: (A): Pole (Pole); (B): Intermunicipal Pole; (C): Belt. Inner areas are classified as follows: (D): Intermediate; (E): Peripheral; (F): Ultraperipheral (Ultraperipheral).

The full Report, which also contains specific regional focuses, can be downloaded from Cittadinanzattiva's website [8]. It was presented on January 19, 2023 in Rome at the European Commission Representation in Italy during the event "Health needs in inner areas, between medical desertification and NRRP."

Tab. 1 - Italy: Community Homes (CH) & Community Hospitals (HH) in Inner Areas

WHAT THE PNRR PROVIDES FOR	Tot. CH	CH in Inner Areas		Tot. OC	Tot. HH	HH in Inner Areas		Municipalities in Inner Areas		Population in Inner Areas	
		(D)	(E-F)			(D)	(E-F)	(D)	(E-F)	(D)	(E-F)
Piemonte	82	10	1	43	27	3	0	241	131	378.090	76.192
Valle d'Aosta	4	1	0	1	1	0	0	28	13	23.860	9.191
Liguria	33	4	0	16	11	4	0	82	36	178.500	24.867
Lombardia	199	22	20	101	66	15	5	254	225	733.774	356.947
Trentino Alto Adige	20	5	7	10	6	1	0	80	138	259.747	303.429
Veneto	95	8	2	49	35	6	2	70	43	288.508	93.373
Friuli Venezia Giulia	23	6	1	12	7	2	0	39	43	105.527	38.947
Emilia Romagna	85	18	14	45	27	6	5	82	79	708.151	284.228
Toscana	77	16	10	37	24	3	4	67	97	498.648	389.879
Umbria	17	2	4	9	5	1	0	33	15	148.330	92.745
Marche	29	5	1	15	9	1	0	63	42	152.458	109.512
Lazio	135	23	7	59	36	7	1	157	58	753.849	197.205
Abruzzo	40	8	12	13	11	3	2	89	113	247.838	212.490
Molise	13	3	8	3	2	1	1	33	71	48.589	152.863
Campania	172	19	17	65	48	8	10	125	165	512.298	458.775

Puglia	121	36	24	40	38	11	8	90	58	1.013.336	426.499
Basilicata	19	2	15	6	5	0	5	24	95	126.614	306.661
Calabria	61	25	12	21	20	6	9	149	131	485.416	341.709
Sicilia	156	48	62	50	43	9	17	119	191	1.151.185	1.160.822
Sardegna	50	14	16	16	13	2	5	103	162	245.009	337.073
TOTAL	**1431**	**275**	**233**	**611**	**434**	**89**	**74**	**1928**	**1906**	**8.059.727**	**5.373.407**

Source: Elaboration of Cittadinanzattiva-Civic Evaluation Agency on data:
CIS-Contratti Istituzionali di Sviluppo [9], 2022 and ISTAT- La geografia delle aree interne nel 2020 [10]

RESULTS

The table shows the number and location of Community Homes (CH) and Community Hospitals (HH) and, for completeness, also Operational Centers (OC) as provided for in the Socio-Institutional Development Contracts, in which some regions have included, in addition to facilities to be built/restructured with NRRP funds, additional facilities to be built/restructured with other funds.

Only a few territorial health services are provided in inner peripheral and ultra-peripheral areas:

- in Valle d'Aosta, where there are 13 municipalities classified as such for 9.191 resident inhabitants, there is neither a Nursing Home nor a Community Hospital. The same goes for the 36 municipalities in the inland peripheral and outermost areas of Liguria, where more than twice as many people reside: 24.867.
- a total of 654.883 Italians residing in the inner peripheral and ultra-peripheral areas of 7 regions have no Community Hospital: these are Piedmont, Liguria, Valle D'Aosta, Trentino Alto Adige, Friuli Venezia Giulia, Umbria and Marche.
- Friuli Venezia Giulia, Marche and Piedmont will each count one Community House for the peripheral and outermost inland areas of their regional territory. Going into detail:
- there will be 1 Community House for the 43 Friulian municipalities in these areas, home to about 39.000 inhabitants;
- only 1 Community House will be available for the nearly 110.000 inhabitants of the 42 municipalities in the Marche region in the inner peripheral and ultra-peripheral areas;
- 1 Community House is planned for the approximately 76.000 people living in the 131 municipalities of Piedmont located in these areas.
- On the other hand, the regions most benefited by the NRRP in terms of the number of Community Homes and Hospitals are, in order, Lombardy (199 Homes and 66 Hospitals), Campania (172 and 48) and Sicily (156 and 43). Of these three regions, only Lombardy is among those with the greatest imbalance between people and health personnel examined.

Fig. 1: Official logo of the EU Project AHEAD

COMMENTS

Inner areas: 508 Homes and 163 Community Hospitals planned in these areas.

The funds and projects included in the NRRP could reduce some historical gaps, such as that of territorial care in some areas of the country. For this reason, Cittadinanzattiva analyzed how many Community Homes (CH) and Community Hospitals (HH) are planned to be built in the inner areas belonging to the 39 provinces where the shortage of health workers is most pronounced. But the results are not encouraging: of the 1.431 Community Houses and 434 Community Hospitals planned in the NRRP, just over a third -- which is 508 Houses, representing 35.5 %, and 163 Hospitals, representing 37.6 % -- will be built in the inner areas. In particular, the greatest risk of depletion is in the ultra-peripheral areas of Liguria and Valle d'Aosta, but looking at the national level, the more than 5 million citizens living in the peripheral and ultra-peripheral areas are at risk of being left almost unprotected: only 16.3 % of the 1431 housing units (i.e., 233) and 17.1% of the 434 community hospitals (i.e. 74) are planned in these areas.

CONCLUSIONS

We envision and desire a Europe in which every citizen has access to sufficient numbers of qualified and motivated health workers, anytime and anywhere. Through work conducted as part of the European AHEAD project "Action for Health and Equity: Addressing Medical Deserts," we aim to help reduce health inequalities by addressing medical deserts in Europe with evidence-based policy solutions.

In Italy, for instance, from the local press and thanks to our daily relationship with citizens and patients, we have information, for example, on the shortage of pediatricians in Cagliari, of general practitioners in Rescaldina and Legnano in the Milan metropolitan area, as well as in Palomonte and Pisciotta in Cilento, of radiologists for reporting Holter examinations in Manfredonia, of gynecologists in the hospital of Mirandola, etc.

Italy lacks reliable, up-to-date and easy-to-find data on the shortage of health professionals, which does not facilitate intervention planning and resource allocation. In fact, the reforms also envisaged by the NRRP will be able to have the hoped-for effects only if the investment in facilities-community homes and hospitals first and foremost-is accompanied by an adequate investment in the workforce. Similarly, it is necessary to dislocate healthcare spaces by strengthening the weak areas of the country, taking into account the nature of the territories and not just an arithmetic logic that looks only at the number of inhabitants. With the aim of prioritizing the issue on the national political agenda, on May 11, 2023 Cittadinanzattiva promoted several initiatives in defense of the National Health Service and for a reform of territorial care that is truly territory-friendly. These included:

1. A national policy dialogue event at the Italian Ministry of Health [11]

Fig. 2: Rome, 11 May 2023, national policy dialogue event at the Italian Ministry of Health

2. A civic mobilization with activists from all over Italy

Fig. 3: Rome, 11 May 2023, citizen mobilization in defence of the National Health Service

3. An online petition

Fig. 4: one of the visuals of the online petition

4. The publication of an updated mapping [12] of health care facilities under the NRRP in partnership with the OpenPolis platform [13]

Fig. 5: cover page of the report on health care facilities envisaged by the NRRP, produced in partnership with the OpenPolis platform

DECLARATIONS

Each of the authors confirms that this manuscript has not been previously published by another international peer-review journal and is not under consideration by any other journal. Additionally, all of the authors have approved the contents of this paper and have agreed to the submission policies of the journal.

AUTHORS' CONTRIBUTION

Each named author has substantially contributed to conducting the underlying research and drafting this manuscript. Additionally, to the best of our knowledge, the named authors have no conflict of interest, financial or otherwise.

CONFLICT OF INTEREST

The authors listed on the first page declare that they do not have any conflict of interest.

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[8] The Report was presented by Cittadinanzattiva on occasion of the **event** "Health needs in inner areas, between medical desertification and NRRP", held in Rome at the European Commission Representation in Italy on January 19, 2023. The Report was edited by Mariano Votta, Head of European Policies of Cittadinanzattiva, in collaboration with his colleagues Maria Vitale, Senior Project Manager, and Bianca Ferraiolo, Head of Cittadinanzattiva's representativeoffice at the European Institutions and Head of the AHEAD Project. Data processing was carried out by Cittadinanzattiva's Civic Evaluation Agency in the persons of Maria Eugenia Morreale and Maria Vitale. Claudia Ciriello,Cittadinanzattiva Project Manager, also collaborated in the data collection. The Report, which also contains specific regional focuses, can be downloaded at this webpage: www.activecitizenship.net/insights/1070-shortage-of-doctors-and-medical-desert-nine-italian-regions-with-the-smallest-workforce.html.html

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Application of the Method of Trigonometrical Substitution in Solving Problems

Dragan D. Obradovic[1], Goran Nestorovic[2], and Dragisa V. Obradovic[3]

1. Department of Mathematics and Informatics, School "Agricultural High School" Pozarevac, Serbia
2. Academy of Technical Vocational Studies Belgrade, Serbia
3. Association of Engineers and Technicians - HTM Pozarevac, Serbia

Abstract:
The use of trigonometric substitution in solving algebraic problems aims to establish a relationship between different branches of mathematics, namely: algebra and trigonometry. It is important to instill in students' courage and resourcefulness in finding ways to solve problems not only in the immediate environment of the conditions, but also in a wider, sometimes unexpected area. Trigonometric substitution is one of many substitution methods of integration where a function or expression in a given integral is replaced by trigonometric functions such as sin, cos, tan, etc. Integration by replacement is a good and easiest approach that anyone can make. It is used when we replace the function, whose derivative is already included in the given integral function. This simplifies the function and gives a function of simple integrals that we can easily integrate. It is also known as u-substitution or reverse chain rule Or in other words, using this method, we can easily evaluate integrals and antiderivatives.

Keywords: mathematics, trigonometric substitution, irrational equations, algebraic solution

INTRODUCTION

In mathematics, trigonometric substitution is the substitution of trigonometric functions for other expressions. In calculus, trigonometric substitution is a technique for evaluating integrals. Moreover, the trigonometric identity can be used to simplify certain integrals containing radical terms. As with other methods of integration by substitution, when evaluating a definite integral, it may be simpler to completely derive the antiderivative before applying the limits of integration.

Work on the use of trigonometric substitution for solving algebraic problems is best organized in optional mathematics classes. At the same time, it is advisable to offer students various problems to solve: rational and irrational equations, inequalities, their systems, tasks for finding the largest and smallest value of a function, tasks with parameters.

It is desirable to create a paper that would contain a selection of different algebraic problems solved by applying trigonometric substitution, not limited to considering a special class of problems.

The Purpose of the Work: to develop a methodology for using trigonometric substitution to solve algebraic problems for students of older grades in optional classes in classes with detailed study of mathematics.

Subject of Study: the process of applying trigonometric substitution as a method for solving various algebraic problems.

Subject of Research: organization of students' activities in mastering trigonometric substitution in elective classes in classes with advanced mathematics.

The study is based on the hypothesis that using a methodology developed on the basis of a comparative analysis of solving a large number of tasks will enable the development of students' creative abilities and preparation for entrance exams at serious universities.

METHODS OF SOLVING IRRATIONAL EQUATIONS

Irrational Equations

Irrational equations are often encountered in entrance exams in mathematics, because with their help it is easy to diagnose the knowledge of concepts such as equivalent transformations, domain of definition and others. Methods of solving irrational equations, as a rule, are based on the possibility of replacing (with the help of some transformations) an irrational equation with a rational one, which is either equivalent to the original irrational equation or is a consequence of it. Most often, both sides of the equation are raised to the same power. Equivalence is not violated when both parts are raised to an odd power. Otherwise, it is necessary to check the solutions found or evaluate the sign of both parts of the equation. But there are other tricks that can be more effective in solving irrational equations. For example, the method of trigonometric substitution.

Example 1: Solve the equation

$$\sqrt{\frac{1+2x\sqrt{1-x^2}}{2}+2x^2}=1$$

Solution Using Trigonometric Substitution

Because $1-x^2 \geq 0$, that $|x| \leq 1$. Therefore, one can put $x=\sin\alpha, \quad \alpha \in \left[-\frac{\pi}{2};\frac{\pi}{2}\right]$.

The equation will take the form

$$\sqrt{\frac{1+2\sin\alpha\cos\alpha}{2}}=1-2\sin^2\alpha \Leftrightarrow \frac{|\sin\alpha+\cos\alpha|}{\sqrt{2}}=\cos2\alpha \Leftrightarrow \left|\sin\left(\alpha+\frac{\pi}{4}\right)\right|=\cos2\alpha$$

Let's put $\alpha+\frac{\pi}{4}=u$ where $u \in \left[-\frac{\pi}{4};\frac{3\pi}{4}\right]$, then

$$|\sin u|=\sin 2u \Leftrightarrow \left[\begin{array}{l} \begin{cases}\sin u \rangle 0\\ \cos u=\frac{1}{2}\end{cases} \\ \sin u=0 \\ \begin{cases}\sin u \langle 0\\ \cos u=-\frac{1}{2}\end{cases}\end{array}\right. \Leftrightarrow \left[\begin{array}{l} u_1=\frac{\pi}{3} \\ u_2=0\end{array}\right.$$

$$x_1=\sin\left(u_1-\frac{\pi}{4}\right)=\sin\left(\frac{\pi}{3}-\frac{\pi}{4}\right)=\sin\frac{\pi}{3}\cos\frac{\pi}{4}-\cos\frac{\pi}{3}\sin\frac{\pi}{4}=\frac{\sqrt{3}}{2}\cdot\frac{\sqrt{2}}{2}-\frac{1}{2}\cdot\frac{\sqrt{2}}{2}=\frac{\sqrt{6}-\sqrt{2}}{4}$$

$$x_2=\sin\left(u_2-\frac{\pi}{4}\right)=\sin\left(-\frac{\pi}{4}\right)=-\frac{\sqrt{2}}{2}.$$

Answer: $\left\{-\frac{\sqrt{2}}{2};\frac{\sqrt{6}-\sqrt{2}}{4}\right\}$.

Algebraic Solution

$$\sqrt{\frac{1+2x\sqrt{1-x^2}}{2}}+2x^2=1\Leftrightarrow\frac{1}{\sqrt{2}}\sqrt{\left(x+\sqrt{1-x^2}\right)^2}=1-2x^2\Leftrightarrow\frac{\left|x+\sqrt{1-x^2}\right|}{\sqrt{2}}=1-2x^2$$

Because $1-2x^2\geq 0$, that $1-x^2\geq x^2$, $\sqrt{1-x^2}\geq|x|$. Means, $x+\sqrt{1-x^2}\geq 0$, so you can expand the module

$$\frac{x+\sqrt{1-x^2}}{\sqrt{2}}=1-2x^2\Leftrightarrow\frac{x+\sqrt{1-x^2}}{\sqrt{2}}=\left(1-x^2\right)-x^2\Leftrightarrow\frac{x+\sqrt{1-x^2}}{\sqrt{2}}=\left(\sqrt{1-x^2}+x\right)\left(\sqrt{1-x^2}-x\right)\Leftrightarrow$$

$$\Leftrightarrow\left(\sqrt{1-x^2}+x\right)\left(\frac{1}{\sqrt{2}}-\left(\sqrt{1-x^2}-x\right)\right)=0\Leftrightarrow\left[\begin{array}{l}\sqrt{1-x^2}+x=0\\ \frac{1}{\sqrt{2}}=\sqrt{1-x^2}-x\end{array}\right.\Leftrightarrow\left[\begin{array}{l}\begin{cases}2x^2=1\\ x\geq 0\end{cases}\\ \begin{cases}4x^2+2\sqrt{2}x-1=0\\ x\geq-\frac{\sqrt{2}}{2}\end{cases}\end{array}\right.\Leftrightarrow$$

$$\Leftrightarrow\left[\begin{array}{l}x=\frac{\sqrt{6}-\sqrt{2}}{4}\\ x=-\frac{\sqrt{2}}{2}\end{array}\right..$$

Answer: $\left\{-\frac{\sqrt{2}}{2};\frac{\sqrt{6}-\sqrt{2}}{4}\right\}$.

Solving an equation in an algebraic way requires a good skill in carrying out identical transformations and competent handling of equivalent transitions. But in general, both approaches are equivalent.

Algebraic Solution

Let's square both sides of the equation

$$x+\frac{x}{\sqrt{x^2-1}}=\frac{35}{12}\Leftrightarrow x^2+\frac{x^2}{x^2-1}+\frac{2x^2}{\sqrt{x^2-1}}=\frac{1225}{144}\Leftrightarrow\frac{x^4}{x^2-1}+\frac{2x^2}{\sqrt{x^2-1}}=\frac{1225}{144}$$

We introduce the replacement $\frac{2x^2}{\sqrt{x^2-1}} = y, \quad y > 0$, then the equation will be written in the form

$$y^2 + 2y - \frac{1225}{144} = 0$$

$$\frac{D}{4} = 1 + \frac{1225}{144} = \frac{1369}{144} = \left(\frac{37}{12}\right)^2$$

$$\left[\begin{array}{l} y_1 = \frac{25}{12} \\ y_2 = -\frac{49}{12} \end{array}\right.$$

The second root is redundant, so consider the equation

$$\frac{x^2}{\sqrt{x^2-1}} = \frac{25}{12} \Leftrightarrow \frac{x^4}{x^2-1} = \frac{625}{144} \Rightarrow 144x^2 - 625x^2 + 625 = 0$$

$$D = 625^2 - 4 \cdot 625 \cdot 144 = 625(625 - 576) = 25^2 \cdot 7^2 = 175^2$$

$$\left[\begin{array}{l} x^2 = \frac{800}{288} = \frac{25}{9} \\ x^2 = \frac{450}{288} = \frac{25}{16} \end{array}\right.$$

Because $x > 0$, that

$$\left[\begin{array}{l} x_1 = \frac{5}{3} \\ x_2 = \frac{5}{4} \end{array}\right.$$

Answer:

$$\left\{\frac{5}{3}; \frac{5}{4}\right\}.$$

In this case, the algebraic solution is technically simpler, but it is necessary to consider the above solution using a trigonometric substitution. This is due, firstly, to the non-standard nature of the substitution itself, which destroys the stereotype that the use of trigonometric substitution is possible only when $|x| \leq 1$. It turns out if $|x| > 1$ trigonometric substitution also finds application. Secondly, there is a certain difficulty in solving the trigonometric equation $\frac{\sin\alpha + \cos\alpha}{\sin\alpha\cos\alpha} = \frac{35}{12}$, which is reduced by introducing a change to a system of equations. In a certain sense, this replacement can also be considered non-standard, and familiarity with it allows you to enrich the arsenal of tricks and methods for solving trigonometric equations.

TRIGONOMETRICAL PROBLEMS OF INCREASED COMPLEXITY

Each educational trigonometric problem is solved on the basis learning activities that should be the subject of purposeful formation in the process of student activity in problem solving. To learn how to solve examples, equations and inequalities well any particular topic, it is necessary to carefully study the theoretical one's material, own formulas, tables, drawings.

Things related to trigonometric equations and inequalities, occupies a significant place in the school mathematics course and we are aware that these themes are widely used in certain sections mathematics, including solving applied problems. Often when solving trigonometric problems of increased complexity different solutions should be considered and which of them should be compared the most rational. One such method in mathematics is the use of trigonometric substitution in solving problems. He is one of the effective methods, especially in cases where needed to solve non-standard tasks.

Indeed, sometimes it is difficult to immediately guess which one substitution must be applied to resolve one or the other mathematical problem. To do this, you must master the basic methods of using trigonometric substitution, be able to analyze the conditions of the task, being able to assign the task to a specific type, etc. In this regard, before using the trigonometric method substitution, it is necessary to repeat the following topics with the students: properties of trigonometric functions; trigonometric formulas; methods solutions of rational, fractional-rational, irrational equations and inequalities, their systems; research and construction of function graphs; finding the largest and smallest value of a function; calculation integral etc.

CONCLUSION

The purpose of this paper is to study some integral problems of fractions. The main methods we used are the trigonometric methods of substitution and variable change for the fractional calculus based on Jumari's modification of the R-L fractional calculus. New multiplication plays an important role in this article. In fact, the results we obtained are natural generalizations of those in classical calculus. On the other hand, the new multiplication we have defined is a natural operation of fractional analytic functions. In the future, we will use these methods to solve problems in engineering mathematics and fractional differential equations.

Modern mathematics education, its harmonization with the requirements of scientific and technological development and progress, permanently requires the introduction of innovations that contribute to the modernization, rationalization and efficiency of the teaching process. In order to comprehensively understand and solve problems related to the teaching and learning of mathematics, mathematics education researchers pay significant attention to mathematical representations, visualization and modern educational technologies, their role and importance for the learning process. Multiple representations, visualization and educational technology, recognized as necessary components of mathematics education, need to be implemented in all segments of teaching, due to their potential to promote mathematical insight and understanding and improve the learning process. The mentioned aspects are particularly important for the study of functions, a fundamental concept of mathematics teaching.

In modern education, one of the important goals is to enable students to understand graphic representations of natural and social phenomena, which is considered a necessary competence in professional and everyday communication. However, regardless of the fact that competences in working with graphic representations are recognized as important outcomes of the teaching process, some experiences and research results (e.g., Leinhardt et al., 1990; Woolnough, 2000) show that many pupils/students have superficial and incomplete knowledge about this important area. The difficulties of some students arise from limited experience in working with graphic representations and their connection with symbolic representations. Such a situation most often arises as a consequence of the way in which the concept of function is processed in schools, when algebraic representations are the focus of learning, while graphic representations and visual approaches to learning are marginalized.

The introduction of materials related to trigonometric substitution in extracurricular classes in classes with a detailed study of mathematics contributes to the development of students' creative abilities and prepares them for university entrance exams with increased requirements for mathematics.

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Comparative Assessment of Heavy Metals in variety of Chicken feeds available in Makurdi Metropolis,Benue State, Nigeria

Gav, B. Lyambee., Oloruntoba, S. O., Nanev, J.D.,and Itse P Silas

1. Dept. of chem., Faculty of Physical Sciences, Joseph Sarwuan Tarka University P.M.B 2373, Makurdi, Nigeria

Abstract:
The research work aimed at investigating some heavy metals in some chicken feeds that are commonly consumed in poultry farms in Benue metropolis. The research analyzed eight (8) metals (zinc, lead, manganese, copper, cadmium, nickel, chromium and iron) in eight (8) samples of chicken feeds from four (4) production companies (top feed, hybrid feed, oracle feed and vita feed), two (2) from each (i.e starter and finisher of each) using atomic absorption spectrophotometer (AAS).In all the samples analyzed, the mean concentration of the metals in the four (4) chicken feeds companies were; vita feed Zn 0.18,Pb 0.75, Cu 0.11, Cd 0.00, Ni 0.31 Cr 0.23, & Fe 3.85, top feed Zn 0.31, Pb 0.25, Cu 0.13, Cd 0.00, Ni 0.10,Cr 0.09, & Fe 2.75,oracle feed Zn 0.19,Pb 0.25,Mn 0.70,Cu 0.15, Cd ND,Ni 0.82, Cr 0.06,& Fe 1.88 and hybrid feed Zn 0.18, Pb 0.63, Mn 0.24, Cu 0.05, Cd 0.00, Ni 0.41,Cr 0.09 & Fe 0.43. This shows that the concentration of the metals was below the WHO acceptable limit. This means that the chicken produced from these feeds are safe for human consumption.

Keywords: heavy metal, chicken feeds, assessment. Comparative

INTRODUCTION

Before the twentieth century, poultry were mostly kept on general farms and foraged for much of their feeds, eating insects, grain spilled by cattle and horses and plants around the farm. This was often supplemented by grain, household scraps, calcium supplements such as oyster shell, and garden waste. As farming became more specialized, many farms kept flocks too large to be fed in this way, and nutritionally complete poultry feeds were developed. Modern feeds for poultry consist largely of grain, protein supplements such as soybean oil meal, mineral supplements and vitamin supplements (Harvey,2019). The quantity of feeds and the nutritional requirements of the feeds, depend on the weight and age of the poultry, their rate of growth, their rate of egg production, the weather (cold or wet weather causes higher energy expenditure) and the amount of nutrition the poultry obtain from foraging. This results in a wide variety of feeds formulations. The substitution of less expensive local ingredients introduces additional variations (Encyclopedia 2018).

Diseases can be avoided with proper maintenance of the feeds and feedser. A *feedser* is the device that supplies the feeds to the poultry. For privately raised chickens, or chickens as pets, feeds can be delivered through jar, trough or tube feedsers. The use of poultry feeds can also be supplemented with food found through foraging. In industrial agriculture, machinery is used to automate the feedsing process, reducing the cost and increasing the scale of farming. For commercial poultry farming, feeds serve as the largest cost of the operation (Wikipedia, 2019).
Poultry (chicken) farming is one of the most important aspects of agriculture with commercial layers and broilers contributing tremendously in meeting the upward protein demand of the

increasing population through eggs and meats. Supplementation of some essential metals such as copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe) in chickens' diets is of great importance. Copper prevents anaemia, while Zn and Mn act as catalysts in many enzymatic and hormonal reactions that are related with growth, immunity and skeletal integrity. Supplementation of Cu, Zn and Mn at 8, 40 and 60 ppm (µg/ml) respectively was recommended in broiler diets by NRC (1994) majorly in term of growth. Hence, the feeds that broiler chicks are fed should be able to cater for their nutritional requirements, of which minerals and certain heavy metals, are extremely integral component; iron being major component of hemoglobin and cytochromes, zinc is needed for DNA structure motifs while copper, manganese, selenium and zinc too are required for proper functioning of enzymes. Zinc and selenium are important for strengthening the immune system and feathering. Arsenic promotes growth and also acts as a coccidiostats. However, Cu deficiency in birds can lead to rupture of the aorta. Diets deficient in Zn causes retarded growth, shortening and thickening of leg bones and enlargement of the hock joint, poor feathering, anorexia and mortality. Chicks hatched from Zn-deficient hens are weak, while a deficiency of Mn in the diet of chickens is one of the causes of perosis (Nasiru *et-al.,* 2015).

Children are highly susceptible to iron toxicity as they are exposed to maximum of iron containing products and chickens are not an exception (Blessing, 2014).

Heavy metals on the other hand are ubiquitous and are being released continuously from man-made sources into the aquatic and terrestrial ecosystems, threatening the health of man and animals. They are potentially dangerous due to their toxicity, bioaccumulation and biomagnification abilities when found within living tissue, and are stored more quickly than they are excreted. The increase in urbanization, industrialization and agricultural activities has been shown to release heavy metals into the environment. In early 2010, there was an incidence of heavy metal poisoning in Zamfara State, Nigeria due to indiscriminate mining by the locals. In Port-Harcourt and other southern parts of Nigeria, heavy metal contaminations of chicken meat, eggs and other products have been reported. Okoye *et al.* (2011) speculated that heavy metals in chicken products could be due to contamination of chicken feeds, the raw materials of which are of various origins. However, little works are available on heavy metal contamination of poultry feeds to confirm this speculation and there is no report of such from the study area (Nasiru *et al*., 2015). In view of the foregoing, coupled with the fact that Benue State is also a northern state as Zamfara State where heavy metal poisoning was recently reported, this study is to embark in order to determine the levels of these metals in commercially made chicken feeds available in Makurdi, Benue state, Nigeria.

Chickens are the main sources of protein for Nigerians and Benue population as well where there are lots of poultry farms and abundant market. Feeds for poultry and sources of raw materials for the production of poultry feeds have been associated with heavy metals pollution (Muhammad *et a*l.,2019). Heavy metal pollution has become a serious health concern in recent years because of agricultural and industrial activities (Nasiru *et al*., 2015). Heavy metals toxicity is a major current environmental health problem and is potentially dangerous because of bioaccumulation and biomagnifications through the food chain and can cause hazardous direct effect on poultry and indirect effect on human health. The impacts of pollution on poultry result in serious economic losses. The risk of heavy metal contamination in meat is of great concern for both food safety and human healthbecause of the poisonous and toxic nature of these metals at relatively minute concentration (Thirulogachandar et al., 2014). This research work is aimed at comparing the level of heavy metal concentration in chicken feeds from different manufacturing companies that are available or sold in Makurdi,,Benue State, Nigeria.

MATERIALS AND METHODS

Study Area

Makurdi is the Headquarter and capital of Benue State located at latitude 6°25′ & 8°8′N and longitude 7°47′ & 10°0′E in middle belt or North central Nigeria with area of 34,059 km^2. The State is the 9th most populous (population of 4,253,641 in 2006 census) Nigerian States, bounded to Nasarawa at the North, Taraba at the East, Ebonyi at the South, Enugu at the South-West and Kogi State at the West. At the South-Eastern part of Benue State, is also bounded with Cameroon.

The town of Makurdi is divided by the River Benue into the north and south banks, which are connected by two bridges: the railway bridge, which was constructed in 1932, and the new dual carriage bridge commissioned in 1978.The southern part of the town is made up of several wards, including Central Ward, Old GRA, Ankpa Ward, Wadata Ward, High Level, Wurukum (Low Level), New GRA etc. Important establishments and offices located here include the Government House, The State Secretariat, The Federal Secretariat, The Central Bank of Nigeria Regional headquarters, Commercial Banks, Telecommunication companies, Police Headquarters, Nigeria Prisons Service, Aper Aku Stadium, Nigeria Air force Base, Makurdi, The Makurdi Modern Market, the Federal Medical Centre, Nigeria Railway Station, Benue Printing and Publishing Company Limited, Radio Benue, Nigerian Television Authority (NTA), Nigerian Postal service, Benue Hotels Makurdi, Benue Plaza hotel, Benue State University, Benue State Breweries (Wikipedia, 2018).

The North bank area of the town have houses among other establishments, the Federal University of Agriculture, the Nigerian Army School of Military Engineering, the headquarters of the 72 Airborne Battalion and the State Headquarters of the Department of Customs and Excise (Wikipedia, 2018).

All these made Makurdi the centre of commercial activities in the State with population of 300,377 in census 2006 & 405,500 projected 2016 (Wikipedia, 2017) and it is characterized with numerous poultry farms which lead to high consumption chicken in restaurants, local food vendors and domestically, as a result, chicken feeds of different companies are available in the metropolis both in wholesales and retails. Therefore, the samples were collected from High level, Low level, Wurukum, North bank market and SRS junction of the Makurdi metropolis.

Figure 1: Map of Benue State showing the sample site (Makurdi).
Source; (Converfresh Team, 2018)

Sample Collection
Eight samples of chicken feeds were collected from four (4) different companies (starter and finisher from Oracle, Vital, Top feeds and Hybrid feeds). The samples were randomly collected by fetching from the bag randomly using hand covered with a extensible hand gloves into a sterilized polythene bag transported immediately to the laboratory for further preparation and analysis.

Sample Preparation
Exactly 2.0 g of each brand of the sample was weighed into different crucibles. 1 cm^3 of concentrated nitric acid was added and then pre-ashed by placing the crucible on a heater until the contents charred. The pre-ashed samples were then transferred into a muffle furnace with a temperature of 480 ^oC for 2-3 hrs after which they were allowed to cool. The cooled samples were dissolved using 5 cm^3 of 30% HCl (hydrochloric acid) and then filtered using Whatman filter papers. The filtrates were individually poured into 50 cm^3 standard volumetric flask and made up to mark with deionized water. These were immediately transferred into prewashed sample bottles (Okoye, 2011; Nasiru, 2015 & Bukar, 2014).

Method of Analysis
The samples in the prewashed sample bottles were then conveyed for analysis of the trace metals using atomic absorption spectrophotometer (Nasiru, 2015 & Bukar, 2014.)

Statistical Analysis
Data obtained from the parameters were evaluated using mean, standard deviation and coefficient of variation percentage. Analysis of variance (ANOVA) was carried out to examine the levels of heavy metals concentration from each brand of sample and across the brand of same

and different companies' understudy. Statistical significance was accepted at a probability level of P less or equal to 0.05 ($P \leq 0.05$).

RESULTS AND DISCUSSIONS

Results

Table 1; Metal concentration (Mg/Kg) of vita feeds

Metals	VTFS	VTFF	$\bar{X}$	S.D	CV%
Zn	0.27	0.10	0.19	0.03	15.79
Pb	0.75	0.75	0.75	0.00	0.00
Mn	0.58	0.39	0.49	0.04	8.16
Cu	0.06	0.16	0.11	0.02	18.18
Cd	ND	0.00	0.00	0.00	0.00
Ni	0.41	0.21	0.31	0.04	6.45
Cr	0.29	0.18	0.24	0.02	8.33
Fe	7.58	0.12	3.85	1.41	36.62

VTFS=Vita feeds starter, VTFF=Vita feeds finisher, $\bar{X}$ =mean, SD=Standard deviation, CV =Coefficient of variation percentage & ND=Non detected.

Table 2; Metal concentration (Mg/Kg) of Top feeds

Metals	TPFS	TPFF	$\bar{X}$	S.D	CV%
Zn	0.58	0.04	0.31	0.10	32.26
Pb	0.50	0.00	0.25	0.09	36.00
Mn	0.88	0.39	0.64	0.18	28.13
Cu	0.16	0.10	0.13	0.01	7.69
Cd	0.00	0.00	0.00	0.00	0.00
Ni	0.21	0.00	0.11	0.04	36.36
Cr	0.06	0.12	0.09	0.01	11.11
Fe	4.65	0.86	2.76	0.72	26.09

TPFS=Top feeds starter, TPFF=Top feeds finisher, SD=Standard deviation, CV%=Coefficient of variation percentage& $\bar{X}$=mean.

Table 3; Metal concentration (Mg/Kg) of oracle chicken feeds

Metals	OAFS	OAFF	$\bar{X}$	S.D	CV%
Zn	0.08	0.30	0.19	0.04	21.05
Pb	0.25	0.25	0.25	0.00	0.00
Mn	0.68	0.71	0.70	0.00	0.00
Cu	0.13	0.16	0.15	0.01	6.67
Cd	ND	ND	ND	0.00	0.00
Ni	0.82	0.82	0.82	0.00	0.00
Cr	0.12	0.00	0.06	0.02	0.86
Fe	0.10	3.67	1.89	0.67	035.45

OAFS=Oracle feeds starter, OAFF=Oracle feeds finisher; SD=Standard deviation, CV%=Coefficient of variation percentage, $\bar{X}$ =mean and ND=Not detected

Table 4; Metal concentration (Mg/Kg) of hybrid chicken feeds

Metals	HBFS	HBFF	$\bar{X}$	S.D	CV%
Zn	0.22	0.14	0.18	0.02	11.11
Pb	0.75	0.50	0.63	0.05	7.94
Mn	0.29	0.19	0.24	0.02	8.33
Cu	0.06	0.03	0.05	0.00	0.06

Cd	ND	0.00	0.00	0.00	0.00
Ni	0.31	0.51	0.41	0.04	9.76
Cr	0.18	0.00	0.09	0.03	33.33
Fe	0.49	0.37	0.43	0.02	4.65

HBFS=Hybrid feeds starter, HBFF=Hybrid feeds finisher, SD=Standard deviation, CV%= Coefficient of variation percentage & $\overline{X}$ =mean, ND=Not detected.

Table 5; Mean concentration (Mg/Kg) of chicken feeds companies

Metals	VTF	TPF	OAF	HBF	$\overline{X}$	S.D	CV%	WHO 2014 STD(mg/kg)
Zn	0.18	0.31	0.19	0.18	0.22	0.02	9.09	40-55
Pb	0.75	0.25	0.25	0.63	0.47	0.08	17.02	10
Mn	0.49	0.63	0.70	0.24	0.52	0.06	11.51	20-60
Cu	0.11	0.13	0.15	0.05	0.11	0.01	9.09	20-60
Cd	0.00	0.00	ND	0.00	0.00	0.00	0.00	3
Ni	0.31	0.010	0.82	0.41	0.39	0.08	20.51	4.5
Cr	0.23	0.09	0.06	0.09	0.12	0.02	16.67	50
Fe	3.85	2.75	1.88	0.43	2.33	0.41	17.60	45-80

VTF=Vita feeds, TPF=Top feeds, OAF=Oracle feeds, HBF=Hybrid feeds, SD=Standard deviation, CV=Coefficient of variation percentage, ND=Not detected & $\overline{X}$=mean.

DISCUSSION

Concentration of Heavy Metals in Chicken Feeds.

Some heavy metals such as iron, manganese, copper, zinc are very important for human life. However, excessive level of these metals can be detrimental. Non-essential heavy metals of particular concern are cadmium, chromium, and lead, although all metals whether essential or non-essential are toxic to animals as well as humans if exposure levels are sufficiently high. The heavy in this work were classified as principal pollutants and toxic for human beings.

Iron (Fe) is an essential element that facilitates the oxidation of carbohydrate, protein and fats. In vita, top and hybrid feeds, the levels of Fe concentration were higher in starter and lower in finisher. In vita feed, the concentration Fe was 7.58 Mg/Kg in starter and 0.12 Mg/Kg in finisher, in top feeds it was 4.65 Mg/Kg in starter and 0.86 Ppm in finisher. In hybrid feeds the concentration was 0.49 Mg/Kg in starter and 0.37 Mg/Kg in finisher. While in top feeds the concentration of Fe was higher in finisher (3.67 Mg/Kg) and lower in starter (0.10 Mg/Kg). The mean concentration of Fe concentration values measured across the companies were 3.85 Mg/Kg, 2.75 Mg/Kg, 1.88 Mg/Kg, 0.43 Mg/Kg, in vita, top, oracle and hybrid feeds respectively. The mean concentration was higher in vita feeds (3.85 Mg/Kg) lowest in hybrid feeds (0.43 Mg/Kg) (Table .5). The values of Fe concentration recorded in this research were within the maximum acceptable limits of 45-80 Ppm for human consumption. The different results obtained from these companies could be attributed to the soil and processing of the raw materials for the production of these feeds from different companies. Bukar & Sa id (2014) reported a higher mean concentration of Fe in chicken feeds of 8.79Ppm. Rohma *et al* (2014) got a higher mean concentration of Fe in poultry feeds (91.86 ± 8.98 Ppm).

The analysis of variance (ANOVA) presented in appendix I revealed that from the sample collected. Starter and finisher have mean values of 0.65 ±1.5 and 0.34 ± 0.66 respectively. The levene's test with p-value of 0.144, indicates non-violation of the assumption for homogeneity of variance. Thus, result of ANOVA (F (1.62 ± 1.141, p=0.290) shows there is no significant statistical differences (p≥ 0.05) in detection of elements between starter and finisher within and across the different companies. The ANOVA between companies feeds samples as presented in appendix II indicates mean values of 0.74 (± 1.84) for Vita feeds, 0.5 (± 1.14) for Top feeds 0.49 (± 0.90) for Oracle feeds and 0.24 (± 23) for Hybrid feeds. The levene's test with p-value of 0.318 indicates non-violation of the assumption for homogeneity of variance. There was no significant statistical difference (p≥0.05) between the companies sampled at (F (3.60) = 0.481 p=0.697). Furthermore, a Turkey pos hoc test affirmed to the ANOVA results indicating no significant difference (p≥ 0.05) within either of the companies.

The ANOVA between the element tested for as presented in appendix III indicates mean values of 0.09 (± 0.08) for zinc, 0.45 (± 0.28) for lead 0.51 (0.23) for manganese, 0.11 (±0.05) for copper, 0.001 (± 0.001) cadmium,0.41 (± 0.30) for nickel, 0.12 (± 0.10) for chromium and 2.23 (± 2.78) for iron. The levene's test with p- value of 0.000 indicates a total violation of homogeneity of variance. There was significant statistical difference (P≤0.05) between the quantity detected per element at (F (7.56) =4.274, P=0.001). Moreover, a Turkey pos hoc test conducted to verify where the difference lies shows significant variation between iron and all the other variables tested. This implies that, the value of iron detected in all feeds varies significantly with other element sampled.

Chromium (Cr) is used in metals alloys and pigments and other materials. Low level exposures to chromium can irritate the skin and cause ulceration. Long term exposures can cause kidney and liver damage and damage circulatory and nerves tissues too (Thirulogochandar, 2014).

Chromium concentration was found higher in starter of all the feeds except top feeds. In vita, chromium concentration was 0.29 Mg/Kg in starter and 0.18 Mg/Kg in finisher, 0.12 Mg/Kg for starter and 0.00 Mg/Kg in finisher for oracle feeds, 0.18 Mg/Kg in starter and 0.00 Mg/Kg in finisher of hybrid feeds. While in top feeds, the concentrations were e 0.06 Mg/Kg in starter and 0.12 Mg/Kg in finisher. The mean concentration of the values of chromium measured across the companies were 0.24, 0.09, 0.09 and 0.06 Mg/Kg for vita, top, hybrid and oracle feeds respectively. The highest concentration of chromium was detected in vita starter was 0.29 Mg/Kg (Table 1) and the lowest in oracle finisher was 0.06 Mg/Kg (Table 3). The values of chromium concentrations discovered in this research were within the W.H.O standard (0.3 Mg/Kg) for human consumption. The different values obtained may be due to the different location where the raw materials were obtained for the feeds production. The chromium content of the feeds was lower compare to the one obtained by Muhammad *et al.,* 2017 (3.02 mg/kg). It was also lower than Imran *et al.,* 2014 (2.32 ± 2.69 Ppm) which was above the W.H.O standard.

The result of analysis of variance (ANOVA) presented in appendix I proved no significant difference (p≥0.05) in detection of chromium between the starter and finisher within and across the different companies. The ANOVA result between companies feeds as presented in appendix II showed no significant statistical difference (p≥0.05) between the various companies sampled. The ANOVA of Cr showed significant difference (p≤ 0.05) in the concentration of Cr examined within and across the companies. However, the mean concentration of Cr was completely at variance with other companies.

Nickel (Ni) is needed by human body in just small amount to produce red blood cells, however in excessive amount can become mildly toxic. Short term exposure to Ni is not known to cause any health problem but long-term exposure can cause decrease in body weight, heart and liver damage, skin irritation (Thirulogachandar, 2014).

In vita and top feeds Ni concentration was high in starter and low in finisher, oracle feeds have the same concentration in both starter and finisher while in hybrid feeds finisher, has higher concentration of Ni than the starter. In vita the concentration of Ni was 0.14 Mg/Kg for starter and 0.21 Mg/Kg for finisher, 0.21 Mg/Kg in starter and 0.00 Mg/Kg in finisher for top feeds, 0.82 Mg/Kg in both starter and finisher for oracle feeds while in hybrid feeds starter 0.31 Mg/Kg and 0.51 Mg/Kg in finisher.

The mean concentration of Ni across the companies was 0.82, 0.41, 0.31 and 0.11 Mg/Kg for oracle, hybrid, vita and top feeds respectively. The highest average was obtained in oracle feeds (0.82 Mg/Kg) (Table 3) while the least was found in top feeds (0.11 Mg/Kg) (Table 2). The Ni concentration value recorded in this work were within the standard range of W.H.O (4.5 Mg/Kg) for the consumption of human.

The variation in the values obtained in this research may be as a result of environmental pollution (Rohma, *et al.,* 2014). The values obtained in the research were above the one obtained by Nasiru, *et al.,* 2015 (0.00-0.19 µg/ml). and below the one in the research of Rohma, *et al.,* 2014 (0.79-4.14 Ppm).while vita starter, hybrid starter, oracle starter and finisher were not detected.

The average concentrations of Cd values calculated across the companies were 0.00 Ppm and non-detected. The 0.00 Ppm was from vita, top and hybrid feeds while the not detected was from oracle feeds (Table 1, 2, 3.4, 4 respectively). The values recorded were within the standard limit of W.H.O (5 Ppm), ERC, 2005 (10 Ppm) and EU (0.5 Ppm). The differences in the values of Cd concentration could be due to its presence in water from tanneries were by the raw materials for the feeds production absorbed it in the soil (Rohma *et al.*, 2014).

These research values were below the one of Rohma *et al*., 2014 (0.44 ± 0.31 Ppm) and also lower than the one obtained by Nasiru, 2015 (0.04-0.46 µg/ml).

The ANOVA result revealed no significant differences ($p \geq 0.05$) in the concentration of Ni between the starter and finisher within and across the different companies. The ANOVA result between companies feeds as presented in appendix (II) showed no significant statistical difference ($p \geq 0.05$) between the various companies sampled. The ANOVA result of Ni showed significant difference ($p \leq 0.05$) in the concentration of Ni detected within and across the companies. But the mean concentration of Ni completely varies with other companies.

Manganese is a very common element that can be found everywhere on earth especially, food stuffs that contain manganese are grains (Thirulogochandar, 2014). The concentration of manganese in vita, top and hybrid were higher in starter than in finisher while in oracle feeds the reverse is the case. The manganese concentration were 0.58 Mg/Kg, 0.39 Mg/Kg, 0.88 Mg/Kg , 0.39 Mg/Kg , 0.29 Mg/Kg , 0.19 Mg/Kg , 0.68 Mg/Kg and 0.71 Mg/Kg in vita starter, vita feed finisher, top starter, top finisher, hybrid starter, hybrid finisher oracle starter, oracle finisher respectively. The highest concentration of manganese was detected in top feeds finisher (0.88 Mg/Kg) (Table 2) and the lowest in hybrid finisher (0.19 Mg/Kg) (Table 4).The mean concentration of manganese was 0.70 Mg/Kg , 0.64 Mg/Kg , 0.49 Mg/Kg and 0.24 Mg/Kg oracle, top, vita and hybrid feeds respectively. The highest manganese mean concentration was in oracle feeds (0.70 Mg/Kg) and the lowest from hybrid feeds (0.24 Mg/Kg).

The values obtained were below the W.H.O limit of (20-60Ppm) for human consumption. The differences in the values of manganese concentration could be traced back to the tanneries as it is present in the effluents being released from tanneries to be absorbed in the soil by plant which may serve as raw materials for the feeds production (Rohma *et al.*, 2014). The values obtained is far lower than that of Okoye, 2011 (26.91-16.74µg/ml) and is within the range obtained by Rohma *et al*., 2014 (0.96 ± 0.01Ppm).

The analysis of variance (ANOVA) result of Mn presented in appendix I showed no significant statistical difference ($p \geq 0.05$) in the analysis of Mn between starter and finisher within and across the various companies. The ANOVA result between the companies' feeds (appendix II) also proved no statistical difference ($p \geq 0.05$) between the various companies sampled. The ANOVA result showed significant difference ($p \leq 0.05$) in the concentration of Mn detected within and across the companies. Also, the mean concentration of Mn completely varies with other companies.

Cadmium (Cd) is highly toxic at midlife. It is a cancer-causing agent and Potentially mutation causing, with sub lethal and lethal effect at low environmental concentration (Rohma *et al.*, 2014).

In vita and hybrid feed, cadmium concentration was not detected in starter while in their finishers was in extremely low amount (0.00 Mg/Kg). In top feeds, the concentration of cadmium was also extremely low in both starter and finisher (0.00 Mg/Kg) while in oracle feeds cadmium concentration was completely not detected in both starter and finisher. In all the samples, the concentration of Cd was negligible in starters and finishers in all the sampled companies. The average concentration of Cd values calculated across the companies 0.00 Mg/Kg and non-detected. The 0.00 Mg/Kg was found in vita, top and hybrid feeds while the non-detected value of Cd was in oracle feeds (Table1, 2, 4 & 3 respectively).

The values recorded were within the standard limit of W.H.O. The differences in the values of Cd could be due to its presence in water from tanneries where by the raw materials for the feeds production absorbed it in the soil (Rohma *et al.*, 2014).

This research values is below the one of Rohma *et al*., 2014 (0.44 ± 0.31) and also lower than the one obtained by Nasiru *et al.*, 2015 (0.04 -0.46µg/ml).

The ANOVA result presented in appendix I indicates no significant difference ($p \geq 0.05$) in the concentration of Cd between the starter and finisher within and across the different companies. The ANOVA result between companies feeds presented in appendix II showed no significant difference ($p \geq 0.05$) between the various companies sampled. The ANOVA result of Cd in appendix III revealed a significant difference ($p \leq 0.05$) in the concentration of Cd analysed within and across the companies. And the mean concentration of Cd was completely at variance with other companies.

Copper (Cu) is an essential element for living organism especially human at low concentration. It is also regarded as micro nutrient in human and function as a co factor for human enzymes (Bukar & Sa id 2014). Too low amount of Cu causes packed cell volume and hence affect healthy growth (Rohma *et al*., 2014). The concentration of Cu in vita and oracle feeds is higher in finisher and low in starter while in top and hybrid feeds the reverse is the case. The concentration of Cu is 0.06 Mg/Kg in vita starter,0.16 Mg/Kg in vita finisher, 0.13 Mg/Kg in oracle starter, 0.16 Mg/Kg in oracle finisher while top feeds starter contain 0.16 Mg/Kg , top feeds finisher 0.10 Mg/Kg , hybrid starter 0.06 Mg/Kg and hybrid finisher 0.03 Mg/Kg . The highest concentration of Cu was from vita starter, oracle finisher and top feeds starter (0.16 Mg/Kg) and the least was from hybrid finisher (0.03 Mg/Kg). The mean concentration of Cu were 0.15 Mg/Kg, 0.13 Mg/Kg, 0.11 Mg/Kg and 0.05 Mg/Kg in oracle, vita, top and hybrid feeds across the companies respectively.

The values recorded for Cu concentration were below WHO ranged (20-60Ppm) or standard. The differences in values may be because of environmental factor where the raw materials were obtained for the feeds production. The values obtained in this work are within the range obtained by Nasiru *et al.*, 2015 (0.04-1.2μg/ml) and is below that of Rohma *et al.*, 2014 (3.18± 1.02Ppm).

The ANOVA result of Cu presented in appendix I showed no significant statistical difference ($p \geq 0.05$) in the amount of Cu between the starter and finisher within and across the different companies. The ANOVA result between the companies feeds as presented in appendix II indicates no significant difference ($p \geq 0.05$) between the various companies sampled. The result of the ANOVA of Cu in appendix III revealed significant difference ($p \leq 0.05$) in the concentration of Cu obtained within and across the companies. And also, the average concentration of Cu was completely at variance with other companies.

Lead being a non-essential element that has direct health concern to both poultry and human, it is therefore contaminant than nutrient (Costa, 2000).

In vita and oracle the concentration of lead was the same for both starter and finisher while in top feeds and hybrid feeds the lead concentration was higher in starter and lower in finisher. The lead concentration was 0.75 Mg/Kg in both vita starter and finisher, 0.25 Mg/Kg in both starter and finisher of oracle feeds, 0.5 Mg/Kg and 0.00 Mg/Kg in top feeds starter and finisher respectively and 0.75 Mg/Kg and 0.5 Mg/Kg in hybrid starter and finisher respectively. The highest concentration was found in vita starter, finisher and hybrid finisher (0.75 Mg/Kg) while the lowest was from top feeds finisher (0.00 Mg/Kg). The mean concentration of lead was 0.75 Mg/Kg , 0.25 Mg/Kg , 0.25 Mg/Kg and 0.24 Mg/Kg for vita, top, oracle and hybrid feeds respectively. The highest value was found in vita (0.75 Mg/Kg) while the lowest (0.24 Mg/Kg) was found in hybrid. The values of lead could be attributed to its presence in the effluent from tanneries which generally emit lead concentration of 4.362 mg/kg (Rohma *et al.*, 2014). The values of lead analyzed are within the W.H.O standard (5Ppm) and is also within the range found by Islam *et al.*, 2007 (0.60-20μ/ml). But the values were lower compare to that of Rohma *et al*, 2014 (4.07 ± 1.81 Ppm).

The analysis of variance (ANOVA) result of Pb showed no significant difference ($p \geq 0.05$) for lead concentration between starter and finisher within and across the companies. The ANOVA result of Pb presented in appendix II revealed no significant difference ($p \geq 0.05$) between the various companies sampled. However, the ANOVA result of Pb presented in appendix III showed a significant statistical difference ($p \leq 0.05$) in the concentration of Pb tested within and across the companies. The mean concentration of Pb as well was completely at variance with other companies.

Zinc (Zn) plays an important role in biochemical path ways and its deficiency can interfere with many biochemical systems such as gastrointestinal tracks, nervous system, skeletal system, immune and reproductive system (Okoye, 2011). Zinc concentration in vita, top and hybrid is high in starter than finisher while in oracle feeds, the concentration was higher in finisher than starter (Table 1, 2, .3 and 4 respectively). The highest concentration of zinc was found in top feeds starter (0.58 Mg/Kg) while the lowest in top feeds finisher (0.04 Mg/Kg). The mean concentration of zinc were 0.31 Mg/Kg , 0.19 Mg/Kg , 0.19 Mg/Kg and 0.18 Mg/Kg in top feeds, vita feeds, oracle feeds and hybrid feeds respectively. The highest average concentration was in top feeds (0.31 Mg/Kg) and the lowest from hybrid feeds (0.18 Mg/Kg) (Table 4.2 and 4.4 respectively). The concentration of Zn in this research is far below the W.H.O standard (40-55 Ppm). Differences in zinc values could be due to industrial waste which can be absorbed by the raw material in their greenish level from soil (source). The zinc content in the feeds is lower than that of Suleiman *et al.*, 2015 (11.65 ± 1.43 µg/ml), Rohma et al 2014 (40.54 ± 6.81 Ppm) and Bukar & sa id, 2014 (32.61 ± 0.01 Ppm).

The analysis of variance (ANOVA) result of Zn realized no significant differences ($p \geq 0.05$) in zinc concentration between starter and finisher within and across the companies (appendix I).In same vein, the ANOVA result of Zn between the companies feeds in appendix II showed no significant statistical difference ($p \geq 0.05$) between the companies sampled. The ANOVA result of Zn in appendix III on the other hand revealed a significant difference ($p \leq 0.05$) in the concentration of Zn examined within and across the companies. The mean concentration of Zn was extremely at variance with other companies.

CONCLUSION

The study has presented data on the comparative assessment of heavy metals in chicken feeds available in Makurdi, Benue State, Nigeria. Heavy metals such as zinc, manganese, lead, nickel, chromium, cadmium, copper and iron were investigated in starter and finisher of four companies (vita, top, oracle and hybrid feeds). The average concentration of the metals were 0.22 Ppm for zinc, 0.47 Ppm for lead, 0.52 Ppm for manganese, 0.11 Ppm for copper, 0.00 Ppm for cadmium, 0.39 Ppm for nickel, 0.12 Ppm for chromium and 2.33 Ppm for iron. And all the mean concentration of the metals falls within the permissible limit of W.H.O for human consumption but needs to be monitored from time to time because it can be bioaccumulated after a long period of time in human bodies after consumption of these chickens.

The result of analysis of variance (ANOVA) revealed that there is no significant statistical difference in detection of the element between the starter and finisher samples. The ANOVA between the companies' feeds showed that there was no significant statistical difference between the companies sampled. The ANOVA between the elements tested showed that there was a significant statistical difference between the quantities detected per element.

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Applications of Artificial Intelligence (AI) in the construction industry: A review of Observational Studies

Adesola O Adeloye, Olayemi Diekola, Ken Delvin, and Chris Gbenga

1. Department of Civil and Environmental Engineering, Federal Engineering Research Institute, Ondo, Nigeria

Abstract:
The construction industry faces numerous complex challenges, including cost and time overruns, health and safety concerns, productivity issues, and labor shortages. Additionally, the industry lags behind in terms of digitalization, making it difficult to address these challenges effectively. However, Artificial Intelligence (AI), an advanced digital technology, has the potential to revolutionize the construction industry, much like it has transformed other sectors such as manufacturing, retail, and telecommunications. AI encompasses various subfields, including machine learning, knowledge-based systems, computer vision, robotics, and optimization, all of which have proven successful in improving profitability, efficiency, safety, and security in other industries. Despite the acknowledged benefits of AI applications, the construction industry still faces several challenges in implementing AI effectively. This study aims to explore the applications of AI in the construction industry, examine the AI techniques currently being utilized, and identify both the opportunities and challenges associated with AI implementation. A comprehensive literature review was conducted to assess existing research on AI applications in construction, focusing on areas such as activity monitoring, risk management, and resource and waste optimization. Through this review, the study highlights the potential opportunities for AI applications in the construction industry, specifically in addressing industry-specific challenges. By leveraging AI technologies, construction companies can improve activity monitoring, enhance risk management strategies, and optimize resource allocation and waste reduction. Furthermore, the study identifies and presents the challenges that need to be overcome for successful AI implementation in construction. These challenges may include issues related to data availability and quality, integration with existing systems, ethical considerations, and workforce upskilling. By providing insights into key AI applications tailored to the construction industry's unique challenges, this study offers a pathway to realize the tangible benefits that AI can bring to the industry. It serves as a foundation for future research and development efforts in harnessing AI's potential to revolutionize construction practices.

INTRODUCTION

The construction industry faces numerous challenges that have hindered its growth and productivity, especially when compared to more digitized industries like manufacturing [1]. Digitization within the construction sector has been slow, primarily due to a long-standing resistance to change [2]. This lack of digitalization and overreliance on manual processes make project management complex and unnecessarily tedious [3,4]. Furthermore, the absence of digital expertise and technology adoption has led to cost inefficiencies, project delays, poor quality performance, uninformed decision-making, and overall low productivity and safety standards [5]. In light of labor shortages, the COVID-19 pandemic, and the need for sustainable infrastructure, it has become increasingly clear that the construction industry must embrace digitization and enhance its technological capacity [6,140–142].

Artificial Intelligence (AI), as a leading digital technology, has made significant contributions to improving business operations, service processes, and industry productivity in various domains [1]. The adoption of AI techniques offers automated solutions and provides competitive advantages over conventional approaches [7]. Subfields of AI, such as machine learning, natural language processing, robotics, computer vision, optimization, and automated planning and scheduling [8], have successfully addressed complex problems and supported decision-making in real-world scenarios. For instance, the manufacturing industry has experienced the fourth industrial revolution, known as Industry 4.0, which emphasizes automation, data-driven technologies, and advanced AI techniques [9]. This revolution has resulted in significant improvements in processes, cost-efficiency, and reduced production times.

Considering the success of AI in other industries, there is immense potential to apply AI techniques in the construction industry. AI can help automate processes, improve project management, enhance safety measures, and optimize resource allocation. By leveraging machine learning algorithms, construction companies can analyze large datasets to gain valuable insights for informed decision-making and predictive maintenance. Computer vision technologies can aid in quality control and monitoring on construction sites, ensuring adherence to design specifications and identifying potential safety risks. AI-driven optimization algorithms can streamline construction schedules, minimize delays, and improve overall project efficiency.
However, several challenges must be addressed to effectively implement AI in the construction industry. These challenges include data availability and quality, integration with existing systems, ensuring ethical use of AI, and overcoming the resistance to change within the industry. Additionally, there is a need for upskilling the workforce to embrace and utilize AI technologies effectively.

In conclusion, the construction industry's low productivity and resistance to change can be addressed through the adoption of AI techniques. AI has proven its value in other industries by enhancing automation, decision-making, and overall productivity. By leveraging machine learning, computer vision, and optimization algorithms, the construction industry can overcome its challenges and achieve significant improvements in project management, safety, efficiency, and quality performance. However, careful consideration must be given to addressing the challenges associated with AI implementation and promoting a culture of embracing technological advancements within the construction industry.

Despite the potential benefits of AI in improving safety and achieving sustainability goals in the construction industry [7,10,11], its adoption and implementation in the sector have been limited. Researchers have published numerous articles on the application of AI and its subfields to address construction-specific challenges. Machine learning has been utilized for health and safety monitoring, cost estimation, supply chain and logistics improvements, and risk prediction [12–15]. Robotics has found applications in site monitoring, performance evaluation, offsite assembly, and managing construction materials, plant, and equipment [16,17,18]. Knowledge-based systems have been employed for tender evaluation, conflict resolution, risk and waste management, and sustainability assessments [19,20]. However, despite these efforts, the construction industry remains one of the least digitized sectors globally, struggling to fully adopt AI and other digital technologies.

Studies have highlighted various challenges hindering the adoption of AI in construction, including cultural barriers, high initial deployment costs, issues of trust and security, talent shortages, limited computing power, and inadequate internet connectivity. However, there are still significant knowledge gaps regarding the research trends in AI applications, future opportunities, and barriers to adoption within the construction industry.

To address these gaps, it is crucial to investigate the following research questions: (1) What are the specific areas of AI application in the construction industry? (2) What are the future opportunities for AI implementation in construction? (3) What are the key challenges to the adoption of AI in the construction industry? Therefore, a critical examination of AI applications in construction is essential to understand current trends, identify opportunities for growth, and recognize barriers to widespread adoption.

The objectives of this study are as follows:

1. Conduct a comprehensive review of existing applications of AI and its subfields in the construction industry.
2. Identify potential areas and opportunities for increased AI implementation in the construction industry.
3. Identify and analyze the challenges affecting the adoption of AI in the construction industry.

This study will make a significant contribution to knowledge by addressing the lack of information on AI in construction. It will provide background knowledge on AI, its types, components, and subfields, and then delve into the existing implementations of AI within the construction industry. By critically examining the applications, opportunities, and challenges associated with AI, this study will shed light on the potential benefits of AI adoption and help inform future strategies for successful integration of AI in the construction industry.

METHODS

To conduct this research, an extensive literature review was performed to identify the existing applications of artificial intelligence (AI) in the construction industry. The review encompassed the period from 1960 to 2023, spanning six decades of AI adoption trends in the construction sector. The SCOPUS database was used as the primary data source, supplemented by other reputable databases such as IEEE, ACM, and Science Direct for full article download and data validation. These databases were selected due to their extensive coverage of high-impact publications in construction, engineering, and computer science.

To ensure a focused search, specific AI techniques were targeted since many studies in the field concentrated on utilizing particular AI approaches to achieve specific goals. A set of twenty-nine free-text keywords encompassing AI subfields and the construction industry was employed, including terms such as "Robotics," "Computer vision," "Machine learning," "Expert System," "Knowledge-based Systems," "Optimization," "Natural Language Processing," and others. Advanced search techniques were employed to enhance the precision of the study.

The search was limited to articles published in English. Conference papers were excluded when keyword searches generated over 100 articles, as the regular practice in the construction domain is to convert conference papers into journal articles. However, in-depth searches were conducted within subfields such as machine learning, knowledge-based systems, and optimization, which yielded a larger number of papers.

Out of the 1700 publications initially assessed, 1142 articles were deemed relevant and included for further investigation. Inclusion criteria focused on articles that described or evaluated AI subfields and their techniques for practical application within the construction industry. The relevance of each article was determined based on the abstract, title, or full-text content when the title or abstract lacked clarity. Key data points, including the application area in construction, methodology/techniques used, and findings, were extracted from each article.

Following the literature review, an overview of artificial intelligence and its subfields was provided. The concept of developing machines with human-like intelligence has its origins in various fields such as philosophy, fiction, computer science, and engineering inventions. Alan Turing's test for intelligence marked a pivotal moment in the field, surpassing traditional theological and mathematical notions regarding the possibility of intelligent machines. Today, intelligent machines outperform humans in various domains, leveraging advancements in technologies like big data and computer processing power.

The three types of AI discussed are Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), and Artificial Super Intelligence (ASI). ANI, also known as weak AI, refers to machines exhibiting intelligence in specific domains, such as chess playing or language translation. AGI, or strong AI, aims to develop machines that can operate at the same level as humans, capable of solving complex problems in different domains. ASI concerns machines that surpass human capabilities across multiple domains.

The major components of AI include learning, knowledge representation, perception, planning, action, and communication. These components represent the various tasks that AI can perform compared to humans. Fig. 1 provides an overview of the types, components, and subfields of AI.

In summary, the research methodology involved an extensive literature review using multiple databases, employing specific keywords and search criteria. The selected articles were thoroughly analyzed, and relevant data was extracted. The overview of AI and its subfields provided a foundational understanding of the subject matter for further investigation.

To understand the current state of AI in the construction industry, it is important to recognize the major subfields of AI. Some of the well-known subfields of AI that have been applied in the industry include:

1. Machine Learning: Machine Learning involves the design and use of computer programs that learn from past data or experiences to make predictions, control systems, or create models. It includes supervised learning (making decisions based on labeled datasets), unsupervised learning (finding patterns in unlabeled datasets), reinforcement learning (learning from interactions with the environment), and deep learning (using neural networks for advanced pattern recognition).
2. Computer Vision: Computer Vision aims to simulate the human visual system by enabling machines to understand and interpret digital images or videos. It involves capturing images, processing them using algorithms, and analyzing them to facilitate decision-making in various construction tasks.
3. Automated Planning and Scheduling: Planning focuses on selecting and sequencing actions to achieve specific goals, while scheduling involves allocating time and resources to accomplish those goals. AI techniques are used to provide solutions for complex planning and scheduling problems, including search techniques, optimization algorithms, and genetic algorithms.
4. Robotics: Robotics involves the design, manufacturing, operation, and maintenance of highly automated devices (robots) that can perform physical tasks. Robots interact with the environment using sensors and actuators, and machine learning techniques, particularly reinforcement learning, are often applied to solve learning problems in robotics.
5. Knowledge-based Systems: Knowledge-based Systems (KBS) use existing knowledge to make decisions. They consist of a knowledge base, an inference engine, and a user interface. KBS can imitate human decision-making in specific domains and are classified into expert systems, case-based reasoning systems, intelligent tutoring systems, and DBMS with intelligent user interfaces.
6. Natural Language Processing (NLP): NLP focuses on creating computational models that mimic human linguistic capabilities. It has applications in machine translation, text processing, speech recognition, and information retrieval. NLP tasks include part-of-speech tagging, named entity recognition, and semantic role labeling.
7. Optimization: Optimization involves making the best decisions or choices within given constraints to achieve optimal outcomes. It is a mathematical discipline that has evolved with AI, and metaheuristic algorithms like genetic algorithms and particle swarm optimization are commonly used.

In the construction industry, AI applications have been trending towards the adoption of machine learning, optimization, robotics, and automated planning and scheduling. Machine learning has gained significant attention due to its potential to address labor and skill shortages, while optimization techniques have been applied to improve productivity. Robotics, particularly with the introduction of technologies like 3D printing and exoskeletons, has also seen advancements in the industry. On the other hand, natural language processing has been less explored in the construction industry.

Recent developments in AI applications in construction have also been influenced by emerging technologies such as quantum computing, Internet of Things (IoT), cybersecurity, and blockchain. Quantum computing offers accelerated problem-solving capabilities that can benefit AI applications. IoT integration with AI enables real-time monitoring, traceability, and energy-saving in construction processes. However, the increasing reliance on interconnected systems and digital technologies also raises concerns about cybersecurity risks in the construction industry. Blockchain technology has found applications in areas like risk management and financial services, but its potential in construction is still being explored.

Overall, AI has the potential to revolutionize the construction industry by improving efficiency, productivity, and decision-making processes. Ongoing research and developments in AI subfields and their integration with emerging technologies will continue to shape the future of AI applications in construction.

To gain insights into the current state of AI in the construction industry, it is essential to understand the main subfields of AI that have been widely applied in this domain. Several prominent subfields of AI that have found applications in the construction industry are:

1. Machine Learning: Machine Learning involves the development and utilization of computer programs that learn from historical data or experiences to make predictions, control systems, or create models. It encompasses various techniques such as supervised learning (making decisions based on labeled datasets), unsupervised learning (identifying patterns in unlabeled datasets), reinforcement learning (learning through interactions with the environment), and deep learning (using neural networks for advanced pattern recognition).
2. Computer Vision: Computer Vision aims to replicate the capabilities of the human visual system by enabling machines to understand and interpret digital images or videos. It encompasses capturing images, processing them using algorithms, and analyzing them to facilitate decision-making in different construction tasks.
3. Automated Planning and Scheduling: Planning focuses on selecting and sequencing actions to achieve specific goals, while scheduling involves allocating time and resources to accomplish those goals. AI techniques are employed to provide solutions for complex planning and scheduling problems, including search techniques, optimization algorithms, and genetic algorithms.
4. Robotics: Robotics involves the design, manufacturing, operation, and maintenance of highly automated devices known as robots that can perform physical tasks. Robots interact with the environment using sensors and actuators, and machine learning

techniques, particularly reinforcement learning, are often applied to address learning problems in robotics.

5. Knowledge-based Systems: Knowledge-based Systems (KBS) utilize existing knowledge to make decisions. They consist of a knowledge base, an inference engine, and a user interface. KBS can imitate human decision-making in specific domains and are classified into expert systems, case-based reasoning systems, intelligent tutoring systems, and DBMS with intelligent user interfaces.
6. Natural Language Processing (NLP): NLP focuses on developing computational models that mimic human linguistic capabilities. It finds applications in machine translation, text processing, speech recognition, and information retrieval. NLP tasks include part-of-speech tagging, named entity recognition, and semantic role labeling.
7. Optimization: Optimization involves making the best decisions or choices within given constraints to achieve optimal outcomes. It is a mathematical discipline that has evolved with the advancement of AI, and metaheuristic algorithms like genetic algorithms and particle swarm optimization are commonly employed.

In the construction industry, AI applications have witnessed a growing emphasis on machine learning, optimization, robotics, and automated planning and scheduling. Machine learning has garnered significant attention due to its potential to address labor and skill shortages. Optimization techniques have been employed to enhance productivity. Robotics, particularly with the introduction of technologies like 3D printing and exoskeletons, has seen notable advancements. However, natural language processing remains relatively less explored in the construction industry.

Recent developments in AI applications in construction have also been influenced by emerging technologies such as quantum computing, the Internet of Things (IoT), cybersecurity, and blockchain. Quantum computing offers accelerated problem-solving capabilities that can benefit AI applications. Integration of IoT with AI enables real-time monitoring, traceability, and energy-saving in construction processes. However, the increasing reliance on interconnected systems and digital technologies raises concerns about cybersecurity risks in the construction industry. Blockchain technology has found applications in areas like risk management and financial services, but its potential in construction is still being explored.

Overall, AI has the potential to revolutionize the construction industry by improving efficiency, productivity, and decision-making processes. Ongoing research and developments in AI subfields and their integration with emerging technologies will continue to shape the future of AI applications in construction.

Table 2: Advantages and Limitations of AI Subfields in Construction

Subfield	Advantages in Construction	Limitations in Construction	References
Machine Learning	- Relevant predictive and prescriptive insights	- Incomplete data	[3]
	- Increased efficiency	- Learning from streaming data, dealing with high-dimensional data, scalability of models and distributed computing	
Computer Vision	- Faster inspection and monitoring	- Total scene understanding	[4]
	- Better accuracy, reliability, and transparency	- Improvement of tracking accuracy and effective visualization of tracking results	
Automated Planning and Scheduling	- Cost savings due to improved processes (e.g., logistics)	- Mostly expensive to implement	[6]
	- Increased productivity	- Could be complex	
Robotics	- Increased safety	- High initial costs	[5]
	- Increased productivity	- Potential job loss due to automation	
	- Improved quality	- Maintenance and repair costs	
Knowledge-based systems	- Easy access to relevant information	- Intellectual property protection and security issues	[10]
	- Easy to update	- Knowledge acquisition issues	
Natural Language Processing	- Increased productivity	- Speech recognition issues such as construction site noise, homonyms, accent variability, etc.	[12]
	- Cost effectiveness	- Data privacy and security issues	
Optimization	- Increased productivity due to optimized processes	- Requires significant computing power	
	- Increased efficiency	- Scalability issues	

Note: References for each subfield's advantages and limitations are provided in the References column.

This study has identified several challenges that affect the adoption of AI in the construction industry. These challenges are discussed below:

Cultural Issues and Explainable AI

The construction industry has been slow to adopt new technologies due to the risky and costly nature of construction processes. Traditional methods are preferred over untrusted technologies. To encourage adoption, AI technologies must be usable in different construction projects and tested thoroughly. Additionally, the use of explainable AI (XAI) is crucial to build trust in AI systems. Construction practitioners need to understand how AI systems make decisions, which can be achieved through approaches like local interpretable model-agnostic explanations (LIME) and layer-wise relevance propagation (LRP).

Security

While AI can enhance security and detect intrusions, it is also a target for exploitation by hackers and cybercrimes. Mistakes in construction processes can have significant implications for quality, cost, and time, affecting the overall project plan and compromising worker safety. Mitigation strategies such as adversarial machine learning need to be employed to minimize security risks. Further research is required to address security issues in emerging AI technologies like computer vision and robotics.

Talent Shortage

There is a global shortage of AI engineers with the necessary skills to drive AI developments across industries, including construction. It is challenging to find AI engineers experienced in the construction sector to develop custom solutions for industry-specific problems. Addressing this shortage requires increased investment in STEM education and collaboration between construction experts and AI researchers.

High Initial Costs

The benefits of AI-driven solutions in construction are undeniable. However, the initial costs of implementing AI technologies, such as robotics, can be prohibitively high. Maintenance requirements also need to be considered. This poses a challenge for smaller subcontractors and firms in the construction industry. Determining cost savings and return on investment is crucial in deciding whether to invest in AI technologies. As these technologies become more prevalent, prices are expected to decrease, making them more affordable for smaller firms.

Ethics and Governance

Establishing public trust in AI technologies relies on inclusive, transparent, and agile governance. Ethical considerations are essential to prevent potential dangers and unfair advantages. Regulations should address issues like decision-making in critical situations and ensure fairness in the construction industry. Building ethics into AI systems and implementing AI safety engineering practices are important steps in addressing these challenges.

Computing Power and Internet Connectivity

Construction sites are often remote and lack reliable power, telecommunications, and internet connectivity. This poses a problem for AI tools that rely on these resources, such as robots and site monitoring systems. Real-time computation and communication can be disrupted. Solutions should be sought to ensure efficient operation despite limited connectivity and power interruptions. The emergence of technologies like 4G and 5G communication can help overcome these challenges.

CONCLUSION

Artificial Intelligence (AI) has the potential to revolutionize the construction industry by improving productivity and addressing various challenges. By leveraging the increasing amount of data generated throughout the building lifecycle and combining it with other digital technologies, AI can enhance construction processes. This study reviewed the application of AI technologies in construction, including computer vision, robotics, natural language processing (NLP), machine learning (ML), automated planning and scheduling, knowledge-based systems (KBS), and optimization.

The study employed a qualitative approach by reviewing publication trends for AI and its subfields over the last six decades using databases like SCOPUS, Science Direct, IEEE, and ACM. The findings classified AI subfields into emerging, ripe, and mature fields in construction research. Computer vision, robotics, and NLP were categorized as emerging technologies, while ML, automated planning and scheduling were considered ripe technologies, and KBS and optimization were identified as mature technologies. The study also developed a hype cycle to predict the duration for each subfield to reach maturity.

Although AI technologies have been applied in construction research, the adoption of recent advancements has been relatively slow. For example, the use of deep learning, which can provide more accurate predictions than conventional ML techniques, has not been widely adopted. Additionally, the study identified opportunities and open research issues for AI in construction, considering emerging trends such as Building Information Modeling (BIM), Internet of Things (IoT), quantum computing, augmented reality, cybersecurity, and blockchain.

The study highlighted challenges hindering the adoption of AI in the construction industry and provided recommendations to address them. The information presented in this study can be valuable for researchers and practitioners in the construction industry, helping them understand the potential benefits and barriers of AI implementation. Construction stakeholders, including regulatory bodies, decision-makers, high-skilled workers, and digital enthusiasts, can utilize this information to define a clear pathway for AI implementation and mitigate potential risks.

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Effects of Different Levels of Plantain Peel Waste on The Amelioration of Crude Oil Polluted Soil

Chuku, O. S. and Amadi, N.

1. Department of Plant Science and Biotechnology, Faculty of Science, Rivers State University, Port Harcourt, Nigeria

Abstract:
The effect on different levels of plantain peel waste in the amelioration of crude oil polluted site was investigated. This experimental research was set up at the Department of Forestry and Environment Ecological Centre Rivers State University. Two kilograms (2kg) of soil were introduced into each of 5 experimental planting bags (EPB) of 5 replications with the following treatment options displayed as experimental planting bag 1, 2 and 3 (EPB1, 2, 3) had spent diesel soil plus 120g, 140g and 160g of plantain peel waste respectively, while EPB 4 had spent diesel soil sample only (control) and EPB5 had unpolluted soil sample alone which was represented as a double control. Result showed that with the application of different levels of plantain peel waste, Increased microbial growth from 1.23 x106 -8.9 x106 cfu/g, 4.8 x106 -5.11 x106 cfu/g, 1.03 x105 -7.6 x104 cfu/g and 2.1 x104 -6.5 x106 cfu/g for THBC, TFC, HUBC and HUFC respectively. Soil physicochemical properties was also influenced with the addition of plantain peel waste. Total nitrogen, phosphorus, potassium and total organic carbon increased from 3.8-5.9%, 0.04-2.1 mg/kg, 13.0-50.2mg/kg and 1.81-5.6% respectively. THC decreased from 2520-485 mg/kg/day, TPH decreased from 1205-329 mg/kg/day while pH decreased from 8.9-6.3. The results suggest that toxic nature of spent diesel and nutrient depletion can be ameliorated with the addition of different concentration of plantain peel waste and should be harnessed as efficient treatment for the restoration of crude oil polluted soil.

INTRODUCTION

In Nigeria, crude oil exploration has a great positive impact on its economic this includes revenue generation, employment opportunities, foreign exchange earnings and much more. Crude oil production process has significant environmental effects throughout its lifecycle, including extraction, transportation, refining, and combustion [1]. The effects of crude oil pollution can be detrimental to ecosystems, wildlife, and contribute to climate change[2]. The soil is an essential component of the biosphere which is referred as *solum* in Latin and it is the top most layer of the earth crust. However, presence of crude oil on soil result in adverse environmental degradation of the ecosystem. The benefits of soil in the survival of living things especially plants and microorganisms is overwhelming. Soil is a basic medium in which plants are anchored, it is an upper parts of earth surface which consist of geological and biological attributes. These layers different of soil play immense function in water and nutrients availability to plants [2,3]. Growth of a plant to its full potential is depends on the suitable environment conditions. Soil properties sensitive to environmental and anthropogenic perturbation serve as indicator to soil quality and these indicators plays crucial roles in supporting plant life. Soil major components include nutrient, essential minerals and innumerable microorganism and its significant functions include:

1. To supply required plant nutrients.
2. The soil stores water necessary in converting elements to ions.
3. It also a habitat for microorganisms.

4. The soil interfaces with lithosphere, hydrosphere, atmosphere, and biosphere [4].

The functionality of a given ecosystem depends on the stability of it soil. However, crude oil spills can have a significant impact on soil which could lead to various environmental and ecological consequences [3]. The presence of some toxic compounds such as benzene and toluene present crude have adverse effects on the overall functioning of the ecosystem [5]. The presence of crude oil on soil also alters the physical properties of soil, impacting on its structure and composition, the hydrophobic nature of crude disrupts oxygen supply and exchange in soil atmosphere and also capable of repelling water, leading to increased soil compaction, decrease in porosity and decrease in nutrient availability for plants [5].

Soil microorganisms play crucial role in maintaining the health and fertility of soil. Crude oil pollution is capable of disrupting the essential role and soil processes of microorganisms through decrease in microbial communities (decline in microbial abundance and diversity) [3]. Crude oil exposure can harm plants in various ways such as plant growth and seed germination inhibition, stunt root development and decrease in photosynthetic rate and leaf transpiration [5]. Numerous remedial techniques adopted in restoration of crude oil impacted soil include physical, chemical, and biological techniques [6]. Microbial degradation is seen as the most environmentally friendly techniques suitable for crude oil mitigation. This form of biological remedial method is faced with numerous challenges such as decrease in soil structure and fertility, reduction in microbial diversity and population, toxicity nature of pollutant and decrease in nutrient availability and uptake [3]. In the quest to address this pitfall face in polluted soil resulted in the use of soil amendments. The addition of any material either organic or inorganic with the objective of improving soil physical, chemical and biological properties especially in a polluted soil is known amendment [2].

Few scientists have investigated the efficacy of organic biostimulants such as poultry manure, pig and goat dung and the use of inorganic biostimulants such as NPK fertilizer. This work seeks to explore the potential of plantain peel wastes as bio stimulating agents in the cleanup of hydrocarbon polluted soil.

MATERIALS AND METHODS

This experimental research was set up at Department of Forestry and Environment Ecological Centre Rivers State University, this area is located in the tropical rainforest region of southern Nigeria which is referred as Niger Delta region. The region has a daily and annual temperatures of 36^{oc} and 28^{oc} [7]. This area shows two main seasons- The rainy season starts from April – October while the dry season starts from November – March. The climatic pattern of this area negatively influences the nutrient pattern with an annual rainfall of 2400mm and high humidity and sunshine [8, 9].

Collection of Soil and Processing of Amendment

A spent diesel oil polluted soil was collected from depth 0-10cm using soil auger behind the central generator plant house while an unpolluted soil was obtained from a farm land situated 300m from the suspected spent diesel polluted site in Rivers State University. The soils were air dried and sieved through a 2mm wire mesh to obtain a homogenous fine fraction of soil composites. The ripe plantain used was source from Kaiama in Kolokuma/Opukuma L.G.A, Bayelsa State is popularly known as 'Beribe'. The plantain peel waste was generated mechanically by hand peeling. The peels (waste) generated from this mechanical process was dried and processed into powder form. The soils and plantain peels waste were analyzed for physicochemical and microbiological properties.

Table 1. Microbial and physicochemical properties of soil

S/N	Parameter	Control	polluted
1	TOC	2.5	4.61
2	TPH	0.8	1450
3	pH	8.4	8.9
4	P	0.05	0.35
5	N	13	4.6
6	K	345	432
7	THBC (cfu/g)	2..1 x 10^5	1.22 x 10^5
8	HUBC (cfu/g)	3.0 x 10^5	1.01 x 10^5
9	TFC (cfu/g)	4.2 x 10^5	1.2 x 10^5
10	HUFC (cfu/g)	3.56 x 10^5	1.1 x 10^5

Table 2. Microbial and physicochemical properties of plantain peels waste

S/N	Parameter	Plantain peels waste
1	Phosphorus (mg/kg)	36.84
2	Potassium (mg/kg)	26,743
3	Nitrogen %	11
4	pH	9.08
5	THBC (cfu/g)	5.0x 10^5
6	HUBC (cfu/g)	6.8 x 10^5
7	TFC (cfu/g)	7.2 x 10^5
8	HUFC (cfu/g)	8.9 x 10^5

Experimental Design and Treatment Application

Two kilograms (2kg) of soil were introduced into each of 5 experimental planting bags (EPB) of 5 replications with the following treatment options displayed as. Experimental planting bag 1, 2 and 3 (EPB1,2,3) had spent diesel soil plus 120g, 140g and 160g of plantain peel waste respectively, while EPB 4 had spent diesel soil sample only (control) and EPB5 had unpolluted soil sample alone which stands as double control. This experiment was monitored for 60 days and weeding was done by handpicking method when necessary. At 60th day, the soil samples obtained from each treatment application were sieved using 2 mm mesh before the determination of microbiological and physiochemical properties the soil which was carried out as follows:

Determination of Soil pH

pH was measured by meter method from slurry of 50/50 (W/V) of sample soil mixed with distilled water in a beaker which was stirred with a stirrer for 5 minutes to homogenize and pH meter (Jennway 3015 model) electrodes were dipped into solution and the pH value displayed in the meter was recorded.

Determination of Phosphorus

Soil samples (2g) were added with 40 ml of Olsen's extracting solution was added which was then filtered using whatmann filter paper. Five (5) ml of the filtrate was measured into 25 ml measuring cylinder and 10 ml of distilled water was added along with 4 ml of B-reagent which was added to 25 ml mark with distilled water. This was allowed for 10 minutes and the absorbance readings was taking using the T60 UV visible spectrophotometer.

Determination of Potassium

Soil samples (5g) were weighed in 100 ml conical flask containing 25 ml of 1 N NHAOAc solution. The mixture was shaken for 5 minutes using mechanical shaker then filtered with whatman No 1. Filter paper. Potassium extract was obtained by Flame Industrial Photometer model 410.

Soil Total Petroleum Hydrocarbon (TPH):

TPH was determined by means of gas chromatograph (HP 5890), fitted with flame ionization detection gadget using soil sample. The soil sample was air dry for 5 days, 2g of the air-dried soil sample was added 10 ml of dichloromethane. The mixture was stirred and allowed to settle and the resultant was filtered through extraction column to obtain a clear filtrate in extraction bottles and concentrated to 2 ml by evaporation. The amount of different petroleum hydrocarbon fractions present in the extract filtrate solution were determined by gas chromatography with Gas Chromatograph (HP 5890 series 11) fitted with flame ionization detection instrument. TPH was obtained as

TPH content = Dilution (if any) x Reading (TPH) x Volume (2ml)

Weight of sample (2g)

Total Organic Carbon, (TOC) %

This was determined by titrimetric method (Walkley-Black techniques). One gram of soil was placed in each of two separate flasks containing 10 ml of 1 $NK_2Cr_2O_7$ solution. The flasks were gently stirred to disperse the sample soil into solution, 20 ml of H_2SO_4 and 100 ml of distilled water were added to each flask after 30 minutes. Four (4) drops of ferroin indicator were added to the solution. The resultant solutions were titrated with 0.5N ferrous sulphate solution. Blank solution (i.e. solution without soil sample) was also prepared and titrated with 0.5N ferrous sulphate solution

TOC = Blank- Titre Value

Wt. of soil sample used (1g)

Soil Total Nitrogen Content

Soil total nitrogen (TN) was determined by spectrophotometry. A blank solution (25 ml of sample supernatant) and sample solution (25 ml of supernatant + nitraver -5 + nitrate reagent powder) were prepared. The blank solution was first placed in a spectrophotometer (HACH, DR/890 colorimeter model) cell holder and the reading of the blank solution as displayed by the spectrophotometer was zero. The blank solution was substituted with the sample solution, and its nitrate content as displayed by the machine was read and recorded.

Microbial Load Determination:

The medium nutrient agar was used for the analysis of total heterotrophic bacteria count (THBC). In preparation of nutrient agar, 28g of the powder was added in 1L of distilled water and characterized by autoclaving at 121°C for 15 minutes and allow to stand for about 45 minutes. It was poured into sterilize Petri dishes and allow to solidify and excess moisture was eradicated from agar by drying in hot air oven set at 60°C. Then 1g of the soil sample was weighed into 9mL sterile diluent (normal saline), to carry out serial dilution. Exactly 0.l ml aliquot of inoculum was aseptically inoculated on duplicated agar surface using a sterile pipette and flame sterilized glass–rod was used to spread the inoculum uniformly and incubate at 37°C for 24 hours followed by colony to obtain colony forming unit (CFU/g)

CALCULATION

Cultivation, Characterization and Identification of Fungal Isolate

A ratio of 1:10 of sample to diluents was prepared. The mixture was shaken and then serially diluted to 10-4. Exactly 0.1 ml was plated on potatoes dextrose agar (PDA) impregnated with 1.0 % lactic acid. The spread plate technique was employed in the cultivation. The plates were incubated for seven (7) days then the probable fungal isolates were characterized.

Microscopically, features like cell shape, type of hypha, presence of spores and spore arrangement were also observed. The cells were first stained prior to microscopic examination. Yeast-like fungal isolates were emulsified on clean, grease free slides with a loop full of water smeared and allowed to dry before fixing. The smears were stained with crystal violet and after 1 min of dryness, the stain was gently washed off using 70 % alcohol. The smear was then gently rinsed with water and allowed to dry. The slide was then examined under oil immersion objective. The isolates were aseptically cut and placed on a clean slide, flooded cotton blue lacto phenol dye and mounted under a cover slip and viewed with the x 40 objective lens. The number of times each fungi occurred divided by the total number of fungi per plate.

Hydrocarbon Utilizing Bacterial and Fungal Count (HUB / HUF)

Bushnell Haas media was prepared by dissolving 3.2g of the salt in a liter of distilled water, and 15grams of agar, the medium was preheated and allowed to cool. The prepared medium was autoclaved at 121°C, 15psi for 15mins. The vapour phase culturing technique was adopted by using a pre-sterilized whattman filter paper, impregnated with Bonny light crude oil and placed on the lid of the petri dishes. The plates were incubated at 37°C for 48 hours. Fungal flora was determined by inhibiting bacterial contamination by addition of 1.0% (v/v) lactic acid to the medium, was poured and allow to solidify at conditions of vapor-phase under ambient temperatures for 7 days.

Data Analysis

The data generated were subjected to statistical analysis of variance (ANOVA) using Statistical Analysis System [10] to test the significant of bio-stimulant on soil characteristics

RESULT AND DISCUSSION

Table 3: Soil microbiological properties.

Treatment	THBC ((cfu/g))	TFC	HUBC	HUFC
EPB1	8.9×10^4	4.9×10^4	6.1×10^4	6.5×10^6
EPB2	8.2×10^6	5.11×10^6	7.2×10^6	3.2×10^4
EPB3	8.4×10^4	5.0×10^4	7.6×10^4	3.8×10^4
EPB4	1.23×10^5	4.8×10^4	1.03×10^5	2.1×10^4
EPB5	1.36×10^6	4.4×10^4	5.32×10^4	4.3×10^4

The effect of different levels of plantain peel treatments on the abundance of soil bacterial and fungi count was observed in table 3. Increment in soil fungal and bacterial population was found in soil amended with plantain peel waste. Total heterotrophic bacterial (THBC) was highest in EPB1 while the least decrease was recorded for EPB4 sampled soil. However, highest increase in total fungal count (TFC) was recorded in EPB2 amended soil with EPB5 (double control) showing the least decrease. Highest increase in hydrocarbon utilizing bacterial count (HUBC) was found in EPB3 soil while least decrease in HUBC was recorded in EPB4. It was also found that plantain peel influenced the concentration of soil hydrocarbon utilizing fungal count (HUFC). The highest in HUFC was recorded in EPB1 treated soil and the least was recorded for EPB4 (polluted soil with og amendment). Increase in HUBC, HUFC, THBC and TFC experienced in soil with various levels of plantain peels waste may be attributed to the treatments added. The treatment contains essential nutrient needed by microbial which is capable of increasing its activities hence leading to an increase in microbial population. This result obtained from this investigation agreed with the finding of [3] that organic amendment has the capacity to influence microbial population and enhanced their activity in a given environment. [11] also explained that biostimulants has the potential to increase microbial growth through mitigating toxicity effect. These results also agreed with [12] who reported that using plant materials as treatment can sustenance higher microbial population since they serve as a source of carbon.

Table 4: Soil physicochemical properties.

Treatment	TN %	P mg/kg	K mg/kg	THC mg/kg/day	TPH mg/kg/day	TOC %	pH
EPB1	5.9	2.1	50.2	485	329	5.6	6.3
EPB2	5.2	1.42	42.2	512.0	444.3	2.12	6.8
EPB3	5.6	2.41	49.5	511.1	473.8	2.5	6.6
EPB4	3.8	0.04	13.0	2520	1205	1.81	8.9
EPB5	2.1	1.13	29.5	0.88	8.87	2.5	5.6

Soil Total Nitrogen Content (TN)

Total nitrogen content was influenced with the addition of different levels of plantain peel waste. There was significant different between and within treatment at (p=0.05). Increase in soil total nitrogen was reported in treated soil and the highest in TN level was in EPB1 amended soil and EPB4 (polluted control soil with og amendment) showed a significant decrease in TN while the least decrease in TN was recorded in EPB5 (unpolluted control soil with og amendment) sampled soil as shown in Table 4. The highest increase in nitrogen content could be attributed to mineralization process obtained through the degradation mechanisms of the plantain peel waste by microorganisms triggered the availability of soil nitrogen. The organic amendment added provided the require energy and carbon required to increase the propensity of microbial activity making them more efficient in converting organic nitrogen into solution phase hence increasing its accessibility. This increase recorded in total nitrogen content could be attributed to the concentration of TN present in the added amendment. The TN content was made available in the soil through microbial metabolism. This finding agreed with Amajuoyi and Wemedo (2015) who reported an increase in biostimulated soil.

Soil Phosphorus

In Table 4, it was also observed that increase in soil phosphorus was more in soil amended with different concentrations of plantain peel waste. There was significant different between and within treatment at (p=0.05). Highest in P concentration was found in EPB3 amended soil while least decrease in P was recorded in untreated polluted soil (EPB5). Soil potassium was also found to increase in its concentration with plantain peel waste amendment. The highest increment in soil P was found in EPB1 while EPB4 showed the least decrease. The increase in soil phosphorus is understandable as the phosphorus content of the plantain peel waste added was above 36 mg/kg. The phosphorus contained in the organic amendment was released after microbial degradation and became available for plant uptake. The result obtained from this investigation agreed with the finding of [11] who reported high phosphorus content in organic amended soil which resulted in the amelioration of crude oil polluted soil.

Soil THC and TPH Content

Decrease in soil concentration of THC and TPH was found in amendment soil with EPB1 showing the least decrease in THC and TPH while the highest increment was found in EPB4 sampled soil (polluted soil with 0g amendment). There was significant different between and within treatment at ($p=0.05$).as shown in table 4. The reduction in total hydrocarbon and total petroleum hydrocarbon levels could be attributed to the organic amendment added.

The organic amendment added is a soil enhancer which may have stimulated and promoted microbial diversity and due to the increased microbial activity leads to enhanced breakdown and degradation of THC and TPH. The increase in THC and TPH levels recorded in the control soil (polluted with 0g amendment) could be attributed to the decrease in microbial activity recorded, the soil was devoid of essential nutrient required to promote microbial growth and enhanced their degradation process. In addition, increase in the concentration of THC and TPH showed the presence of crude oil contamination. This result agreed with [6] who reported that crude oil is composed of 83-89% carbon and therefore its presence in soil is capable of influencing the presence of TPH and THC. The decrease in TPH and THC recorded in the polluted treated soil could be attributed to the organic amendment added. The added amendment contains essential nutrient which has the potential to stimulant microbial growth when incorporated into soil resulting in decrease in soil TPH and THC. This finding agreed with [13] who reported similar result on the effect of microbial population in crude oil biostimulated soil.

Soil Total Organic Carbon Content & pH

Soil total organic carbon was found to increase with treatment addition. There was significant different between and within treatment at ($p=0.05$). Highest increase in TOC was found in EPB1 sampled soil because the least was recorded in EPB4. Decrease in pH level was recorded with amendment addition of various concentrations. The least decrease in pH was in EPB1 treated soil while highest increment in pH was recorded in EPB4.

The increase in TOC content recorded in the amended soil could be attributed to the type and concentration of amendment used. The TOC content in the plantain peel waste treatment was not readily decomposed by microorganisms. The finding corroborated with the report of [14] who reported an increase in TOC in sawdust amended soil and concluded that TOC embedded in the sawdust treatment was not made available as readily source of food energy for microorganisms hence increase in its concentration was found. This also disagrees with the report of [15] who recorded a significant decrease in TOC content in soil containing readily degradable soil enhancers. The addition of amendment influenced pH levels; optimal pH was achieved with addition of amendment. pH values decreased from 8 to 6. Decrease in pH level could be attributed to mineralization process achieved during degradation of plantain peels waste. This result agrees with [3] who reported a reduction in the level of soil pH in an enhanced soil.

CONCLUSION

This research investigated the capacity of plantain peel of different levels to reduce TPH, TOC, THC and to increase microbial and fungi population. This study demonstrated that plantain peel waste amelioration was effective in the restoration of crude oil polluted soil since it stimulated microbial growth leading to decrease in hydrocarbon content. Therefore, the use of plantain peel waste to facilitation polluted soil restoration process is recommended.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

DECLARATIONS

Each of the authors confirms that this manuscript has not been previously published by another international peer-review journal and is not under consideration by any other journal. Additionally, all of the authors have approved the contents of this paper and have agreed to the submission policies of the journal.

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