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GEOTECHNICAL INVESTIGATION OF BOLE DAM SITE, YOLA SOUTH LOCAL GOVERNMENT AREA, ADAMAWA STATE, NIGERIA

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Abstract

Bole Dam site falls in North Eastern Nigeria is underlain by Bima Sandstones. The lithology comprises semi-consolidated sandstone, siltstone clay. This research investigated the suitability of the site for dam construction by conducting geotechnical analyses on soil samples obtained from the area. The plasticity of the soils ranges from low to medium showing that most of the soils are inorganic soils. The percentage finer of the soil samples passing No 200 sieve range between 23.0% and 37.0% in all the sampled soils; indicating well-graded sands and silty sands, with low-clay-material content. The specific gravity G_s vary from 2.65 to 2.68; indicating predominance of sands and silty sands; hence the soils are classified as A-2-6 and A-2-4. The Maximum Dry Density (MDD) range from 1.83g/cm^3 at Optimum Moisture Content (OMC) of 7.6% to 2.08g/cm^3 at OMC of 7.0%; indicating gradual response to compaction. The soaked CBR range between 11% and 25% while the unsoaked CBR range from 52% to 68%. These indicate that the soils are good and suitable for embankment and damming purposes. The angles of internal friction range from 4° to 50° while the [redacted] cohesion values vary between 23kPa and 185kPa. These variations indicated that the soils are characterized by different grain sizes, well graded and good soils for dam purpose. The coefficients of permeability range from 6.339 x10^{-7} cm/sec to 5.581 x 10^{-5} cm/sec; indicating very low permeability, semi pervious soils, with very low transmitting capacity, hence suitable for dam siting.

Keywords:
Geotechnical, Atterberg limits, Compaction, Specific gravity, Natural Moisture Content.

Introduction

A dam is a seal placed in a river to impound the stream flow for power generation, irrigation or water supply. Its construction involves impoundment of large water bodies and requires the understanding of the general geological setting within the proposed site (Bayewu, et. al., 2015). It must be stable under all loading conditions and resist hydrostatic

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pressures on its upstream face, destructive influences of water percolation and possible uplift due to it (Leulalem, et. al., 2016). Adequate assessment of site geotechnical conditions is an important aspect of dam safety evaluation. Evaluation of the safety of a dam site requires that its foundation be adequately investigated to identify the factors that critically affect its safe performance (Katty, et. al., 2024).

Dam site geotechnical studies remain prerequisites to obtaining preliminary estimate of the strength of the rock mass (Bayewu, et. al., 2015). These are needed to assess the suitability of an area for founding of a dam and enable the preliminary design and stability evaluation of the proposed structure. It also forms the basis for determining the type and extent of further investigations to be conducted during the final phase of the study and during design (Konwea, et. al., 2021).

A dam is a wall of solid material built across a river to block the flow of the river thus storing water in the lake that will form upstream (Bayewu, et. al., 2015); its construction and filling of the reservoir behind it create load stresses on the floor and sides of a valley that did not exist previously (Leulalem, et. al., 2016).

Assessment of site conditions is an important aspect of a dam safety evaluation. Evaluation of the safety of a dam requires adequate investigation of its foundation (Perloff, et. al., 2016). Bayewu, et. al., (2015), opined that, when investigating a dam project the researcher is concerned with the geology of the dam site including the foundation for the dam itself and the sites for other structures such as spillway and diversion tunnel, the geology of the area to be occupied by the reservoir once the dam is completed and the sources of the construction materials.

Foundations of a dam can either be rock foundation or alluvial foundation. High dams are usually constructed on rock foundations. Moreover, the spillways and outlets are normally built on sound rock. The presence and nature of clay in the seams of the jointed or fractured zones of the rock should be specially investigated. Such materials create problems and may even lead to failure when the reservoir is filled and very high hydrostatic pressure develops (Sabinus, et, al., 2023). The depth of exploratory investigations should be taken up to the bed rock. If the bed rock is at great depth, there should be at least one boring up to the bed rock. Alluvial foundations consist of sand, gravel, silt and clay. Generally, earth dams and low gravity dams are constructed on such foundations. The properties of soils such as permeability, density, consolidations characteristics and shear strength are determined.

This research is therefore an attempt to investigate the possibility of constructing an earth dam across River Chochi in Bole area for the purpose of dry season farming; to determine the dynamic behaviour of the foundation area within the dam environment.

Problem Statement/Justification

Bole area in Yola South Local Government Area of Adamawa State has an expansive, fertile land good for crop cultivation. However, being located in the savannah region where rainfall is seasonal, cultivation of crops is often hindered by inadequate rainfall (Adebayo, et. al., (2021). Underground water source is low yielding due to the deep nature of the water table. The farmers cultivate the land only during the rainy season resulting to underutilization. The solution is to construct a dam to provide water for dry season irrigation farming. It is in line with this challenging demand that

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this project is proposed with the aim of delineating the possibility of constructing an earth dam across the River Chochi which traversed the area to enable the farmers engage in dry season irrigation farming for maximum land utilization and more food production. Water can be stored in the reservoirs during the rainy season and released/distributed over the land in the dry season. Usually, the water flows under the influence of gravity or pumped onto the land. This project if successful can provide solution to water problem for dry season farming in the area.

Aim and objective s of the study

This research is aimed at providing dam designers with necessary information for safe dam structure and to estimate the cost with reasonable accuracy. The following are the objectives of the study:

a. To interpret satellite images and aero-photographs by reconnaissance survey;
b. To examine the geological and topographical survey of the study area by preliminary exploration;
c. To determine the rock types by thorough geological mapping of surface rock outcrops;
d. To determine the depth of overburden and estimate the geological structures present;
e. To determine the engineering properties of soils present;
f. To verify the geological structures at the dam site by test drillings and permeability tests;
g. To investigate the availability of construction materials.

The Study Area

The research will be carried out in Bole, Yola South Local Government Area of Adamawa, North eastern Nigeria. The area is located between longitudes 12°66' E - 12°98' E and Latitudes 9° 06' N - 9°46' N and is underlain by the Cretaceous Bima Sandstones; a sedimentary unit of the Yola Arm of the Upper Benue Trough (Ntekim, 2018). It has a tropical climate characterized by distinct dry and wet seasons. The mean annual rainfall ranges from 850 mm to 950 mm; with August and September being the wettest months. The area experience high temperatures between March and June (up to 42°C) and temperatures in December and January (as low as 20°C). The relative humidity rises up to 90% in the wet season and reaches its peak in August and September (Adebayo, et. al., 2015). The area is drained by river Mayo Chochi; which is seasonal; reaching its peak in August/September and flowing eastwards to empty its water to the nearby River Benue.

Geotechnical surveys

Diamond core drilling was carried out to recover undisturbed samples of about 50 mm in diameter from depths of a few metres. Disturbed samples were also used in some circumstances and are taken to laboratory to determine their engineering properties such as direct shear, unconfined and triaxial compression, moisture content, consolidation, compaction, Atterberg limits, grain-size analysis, and permeability. Laboratory tests were also necessary to establish the quality of construction materials such as concrete aggregate, impervious material, rock fill, and riprap. The results of geotechnical analyses were interpreted in accordance with BS 1377: (2021) standards and inferences drawn for the engineering quality of the soils and their suitability for dam design and construction.

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Results and Discussion

The engineering properties of soil samples as obtained from laboratory analyses for moisture content, particle size distribution, atterberg limits, specific gravity, compaction, permeability, shear strength and California bearing ratio are presented in this section. The analyses were carried out in accordance with the British Standard Institution (BS 1377).

Table 1: Natural Moisture Content, Atterberg Limits and States of Plasticity of the Sampled Soils

Sample	Depth (m)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	State of plasticity
Pit 1	0.5	4.42	19.45	9.63	9.82	Low
	1.0	3.78	19.32	9.67	9.65	Low
	2.0	6.84	23.77	7.33	16.44	Medium
	3.0	5.11	25.71	9.35	16.36	Medium
Pit 2	0.5	6.63	26.11	15.99	10.12	Medium
	1.0	5.26	20.27	10.41	9.86	Low
	2.0	5.77	18.21	8.44	9.77	Low
	3.0	5.65	18.95	9.30	9.65	Low
Pit 3	0.5	4.55	17.52	10.99	6.53	Low
	1.0	6.87	21.15	11.26	9.89	Medium
	2.0	6.18	20.71	7.93	12.78	Medium
	3.0	6.94	19.36	8.09	11.27	Medium
Pit 4	0.5	5.15	18.52	9.06	9.76	Low
	1.0	5.96	21.18	11.64	9.54	Low
	2.0	5.32	22.64	7.80	14.84	Medium
	3.0	4.86	21.46	7.74	13.72	Medium
Pit 5	0.5	4.39	20.64	9.32	11.32	Medium
	1.0	4.12	25.37	14.92	10.45	Medium
	2.0	5.86	24.53	10.78	13.75	Medium
	3.0	5.54	26.28	11.84	14.44	Medium
Pit 6	0.5	6.12	18.59	10.95	7.64	Low
	1.0	5.34	19.23	10.26	8.97	Low
	2.0	5.75	20.94	7.73	13.21	Medium
	3.0	4.95	21.84	7.19	14.65	Medium
Pit 7	0.5	4.74	17.91	8.18	9.73	Low
	1.0	5.21	18.24	8.32	9.92	Low
	2.0	5.55	23.56	7.71	15.85	Medium
	3.0	6.31	22.93	7.61	15.32	Medium
Pit 8	0.5	5.64	26.15	15.57	10.58	Medium
	1.0	6.13	24.32	14.53	9.79	Low
	2.0	6.45	23.75	14.52	9.23	Low
	3.0	5.56	20.36	11.95	8.41	Low
Pit 9	0.5	4.64	18.44	10.74	7.70	Low
	1.0	5.15	19.26	11.10	8.16	Low
	2.0	5.85	25.25	14.60	10.65	Medium
	3.0	5.32	24.74	13.85	10.89	Medium
Pit 10	0.5	4.44	19.48	10.64	8.84	Low
	1.0	4.86	18.78	9.35	9.43	Low

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Sample	Depth (m)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	State of plasticity
	2.0	5.52	24.84	9.82	15.02	Medium
	3.0	5.12	23.65	9.01	14.64	Medium

Natural Moisture Content

Table 1 shows the natural moisture content **NMC** of the sampled soils. The moisture-density relationship when comparing strength of the soil is based on both mechanical and strength, there should be increase moisture content with increase in the number of blows. There appear to be increase in OMC (%) as the number of blows increases (Alam, 2015). It can therefore be stated that there is little or no need to further increase the number of blows so as not to cause further damage of the soil samples. There is increase in moisture content due to increase in density; also there is increase in water content (%) due to increase in the number of blows.

Atterberg Limits

The atterberg limits (Table 1) shows the relationship between liquid limits, plastic limits and plasticity indexes of the sampled soils. The values of plasticity indexes indicate that most of the soil samples obtained at depths 2.0 – 3.0 m fall within the medium plasticity. Soils with medium plasticity are usually semi-impervious, hence, will be suitable for damming; due to their higher compressibility (Mahmut, et. al., 2020). As shown in Table 3, the liquid limits for all the sampled soils are below 50%, hence, the Unified Soil Classification USC shows that they are classified as CL, OL and ML; corresponding to organic or inorganic soils with slight plasticity. The plasticity indices of all the sampled soils range from 6.55 % to 16.36 %; indicating that the state of plasticity of the sampled soils range from Low to Medium (Sabinus, et, al., 2023).

Table 2: Index of soil samples

SN	SIEVING % PASSING NO 200	Specific Gravity Gs	CLASSIFICATION
Pit 1	37.0	2.68	A-2-6 (1)
Pit 2	23.0	2.65	A-2-4 (0)
Pit 3	27.0	2.67	A-2-4 (0)
Pit 4	23.0	2.65	A-2-4 (0)
Pit 5	35.0	2.66	A-2-6 (0)
Pit 6	37.0	2.68	A-2-6 (0)
Pit 7	23.0	2.65	A-2-4 (0)
Pit 8	27.0	2.67	A-2-4 (0)
Pit 9	23.0	2.65	A-2-4 (0)
Pit 10	35.0	2.67	A-2-6 (0)

Particle Size Distribution

The percentage finer of the soil samples passing No 200 sieve range between 23.0% and 37.0% in all the sampled soils (Table 2). This indicates that the subsoils are classified as well-graded sands and silty sands, with low-clay-material content. Going by the Federal Ministry of Works and Housing

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(2021) recommendation of 35%, the tested soils are rated good; having suitable engineering properties for foundation of civil engineering structures.

Specific Gravity (G_s)

The specific gravity G_s of the tested soils vary from 2.65 to 2.68 (Table 1); indicating they are predominantly sandy and silts sands (Adewoye, et. al., 2015). G_s are linked with mineralogy; reflect history of weathering and relatively important for evaluating the qualitative behaviour of the soil and points to the suitability of the soil in construction. Soils with higher values of G_s give more strength for foundations. G_s vary with the soil texture and within different fractions. It is been used as a measure of the degree of maturity, i.e. lateritization. Lower G_s values indicate a coarse soil and vice versa (BS1377, 2021). For the studied soil samples, the G_s fall within the range specified by Perloff, et. al., (2016).

Classification

The particle size distribution, specific gravity and atterberg limits of the studied soils were used in classifying the studied soils. Sampled soils from Pit 1, Pit 5, Pit 6 and Pit 10 are therefore classified as A-2-6; while sampled soils from Pit 2, Pit 3, Pit 4, Pit 7, Pit 8 and Pit 9 are A-2-4 (Arora, 2017).

Table 3: Engineering properties of soil samples

SN	OPTIMUM MOISTURE CONTENT O.M.C (%)	MAXIMUM DRY DENSITY MDD (g/cm^3)	C.B.R AT OMC SOAKED (24 HRS)	C.B.R AT OMC UNSOAKED (%)
Pit 1	8.7	1.85	25.0	63.0
Pit 2	8.4	1.95	-	60.0
Pit 3	7.6	1.83	11.0	68.0
Pit 4	6.3	1.97	18.0	54.0
Pit 5	7.0	2.08	17.0	52.0
Pit 6	8.7	1.85	25.0	63.0
Pit 7	8.4	1.95	-	60.0
Pit 8	7.6	1.83	11.0	68.0
Pit 9	6.3	1.97	18.0	54.0
Pit 10	7.0	2.08	17.0	52.0

Compaction

When two soil samples are compacted at the same level, the sample with higher Maximum Dry Density at lower Optimum Content is regarded as best for foundation; and when one sample is compacted at two different levels, the level that gives the higher Maximum Dry Density at lower Optimum Moisture Content is said to be better (Arora, 2017). In this study, the sampled soils were compacted at the same level. The Maximum Dry Density (MDD) of the sampled soils range from 1.83g/cm^3 at Optimum Moisture Content (OMC) of 7.6% to 2.08g/cm^3 at OMC of 7.0% (Table 3); indicating that the soils respond gradually to compaction. Compaction is important in improving the desirable load bearing properties of soil as a foundation material. High values of MDD indicate soil quality and suitable soil property and low OMC points to workability of good subsoil (Perloff,

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et. al., 2016). The studied soils are suitable for foundation, embankment and damming because the values of MDD of all samples exceed 1.700g/cm^3. The OMC and LL increase with the increase in percentage of fines as expected. Hence, grading and plasticity influenced the MDD and OMC of soils in study area (Arora, 2017).

California Bearing Ratio (CBR)

California Bearing Ratio (CBR) test is testing a soil sample after compaction at Optimum Moisture Content (OMC). It is used to evaluate the strength of subsoil and also to determine the quality of construction materials; and it was conducted on disturbed soil samples (Varoujan, et. al., 2019). The value of the test at the bottom will be higher than the top due to the compaction rate. From Table 3, the soaked CBR between 11% and 25% and the unsoaked CBR ranges from 52% to 68%. The result of the unsoaked CBR indicates that all the sampled soils are rated as good soil and can be used as for embankment and damming purposes.

Comparing with earlier test results, the CBR values are directly proportional to G_s and MDD; and inversely proportional to the NMC, OMC and LL; indicating that as CBR increases strength of subsoil also increases (Yashas, et. al, 2016). Field density, dry density, bulk density and cohesion of soil are directly proportional to CBR. As the density of soil increases the soil particles become more compact to carry more loads or stresses. Therefore as CBR increases, strength of foundation subsoil also increases.

Table 4: Shear strength parameters and permeability of the Soils

SN	δ3(kPa)	δ1(kPa)	C (kPa)	Φ deg.	Permeability K (cm/secs)
Pit 1	300	431	185	19	4.135 x10^{-7}
Pit 2	97	140	54	41	6.339 x10^{-7}
Pit 3	97	135	35	47	1.590 x10^{-5}
Pit 4	300	432	48	4	1.756 x10^{-5}
Pit 5	97	151	58	45	7.967 x10^{-6}
Pit 6	97	182	69	50	9.241 x10^{-6}
Pit 7	300	1134	185	19	4.543 x10^{-7}
Pit 8	300	543	49	8	4.478 x10^{-7}
Pit 9	450	662	23	9	4.046 x10^{-7}
Pit 10	97	156	56	46	5.581 x10^{-6}

Note: OMC=optimum moisture content; MDD= Maximum Dry Density, δ3= confining stresses of soil;δ1= Uniaxial stress of soils; C=Cohesion and Φ=friction angle

Shear Strength of Soils (Unconsolidated-Undrained)

Shear strength of a soil mass is an important design input parameter needed for geotechnical design of engineering structures (Sabinus, et, al., 2023). In this study, shear strength tests were carried out on sampled soils and the results are indicated in (Table 3). The angles of internal friction of the sampled soils range from 4° to 50° while the cohesion values vary between 23kPa and 185kPa. The variation of the angles of internal friction indicated that the soils are characterized by

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approximately different grain sizes and which well graded and the disparity of the cohesion values indicate good soils for dam purpose (Arora, 2017).

Permeability

Permeability of a soil mass is its ability to allow water to flow through it easily. The permeability of an impervious soil is very low and water cannot flow through it (Lambe, 2017). Soils with coefficient of permeability greater than 10^{-3} mm/sec are classified as pervious; while those with a value less than 10^{-5} mm/sec are impervious. Soils with the coefficient of permeability between 10^{-5} to 10^{-3} mm/sec are designated as semi – impervious (Arora, 2017). In this study, the values of coefficients of permeability range from 6.339 $x10^{-7}$ cm/sec to 5.581 x 10^{-5} cm/sec. The sampled soils from all the Pits have very low permeability, which classifies them as semi pervious soils, with very low transmitting capacity, which is an important parameter for the suitability of dam siting (Lambe, 2017). Their permeability standard is very slow class; indicating very poor drainage property.

Conclusion

Bole Dam site falls within the Upper Benue sedimentary basin in North Eastern Nigeria. The area is underlain by the Cretaceous Bima Sandstones. The lithology comprises semi-consolidated sandstone, siltstone clay. In an attempt to investigate the suitability of the site for dam construction, geotechnical field and laboratory analyses were conducted on disturbed and undisturbed soil samples obtained from the area. The atterberg result shows the state of plasticity of the soils range from low to medium which shows that most of the soils are inorganic soils. The percentage finer of the soil samples passing No 200 sieve range between 23.0% and 37.0% in all the sampled soils; indicating that the subsoils are well-graded sands and silty sands, with low-clay-material content. The specific gravity G_s vary from 2.65 to 2.68; indicating predominance of sands and silty sands; hence the soils are classified as A-2-6 and A-2-4. The Maximum Dry Density (MDD) range from 1.83g/cm^3 at Optimum Moisture Content (OMC) of 7.6% to 2.08g/cm^3 at OMC of 7.0%; indicating gradual response to compaction. The soaked CBR range between 11% and 25% while the unsoaked CBR range from 52% to 68%. These indicate that the soils are good and suitable for embankment and damming purposes. The angles of internal friction range from 4° to 50° while the cohesion values vary between 23kPa and 185kPa. These variations indicated that the soils are characterized by different grain sizes, well graded and good soils for dam purpose. The coefficients of permeability range from 6.339 $x10^{-7}$ cm/sec to 5.581 x 10^{-5} cm/sec; indicating very low permeability, semi pervious soils, with very low transmitting capacity, hence suitable for dam siting.

Recommendations

- It is recommended the type of dam that will be most suitable for the site is an earth dam.
- In-situ field tests should be conducted to provide field measurements of soil properties on the site at more appreciable depth in order to enhance better study of the competence of the subsurface layers for dam siting.

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References

Adebayo, A.A., and Tukur, A.L., (2021). Adamawa State in maps. Paracellette, Yola, Nigeria, pp 32-36.

Adewoye, A., Ajayi, P., and Adegbola, A., (2015). Investigation of a Proposed Dam Site along River Adunin, Ogbomoso, Southwestern Nigeria. LAUTECH Journal of Engineering and Technology, Volume 10, Number 1, pp 6-22.

Arora K.R. (2017), Civil Engineering Department, Engineering College, KOTA (Raj.), Soil factor diagrams. Journal of Geotechnical Engineering Division, ASCE, 104(8)

Bayewu, O.O. and Oloruntola, M.O. (2015). Preliminary Investigation Of A Proposed Dam Site Along River Ome, Ago Iwoye South Western Nigeria. Bulletin, International Association of Engineering Geologists, Vol. 52, pp 3-8.

British Standards 1377 (2021). Methods of Tests for Soils for Civil Engineering Purposes. British Standard Institution. 2 Park Street, London. W1 A2BS.

Federal Ministry of Works and Housing (2021): Foundation Manual Part 3, Dam Design, Federal Ministry of Works and Housing, Abuja.

Katty, F.F., Ankidawa, B.A., Obiefuna, G.I., Valdon, Y.B., and Kwami, I.A., (2024). A Proposed Investigation Using Integrated Geophysical and Geotechnical Methods: A Case Study of Loko Area, Northeastern Nigeria. Global Journal of Geological Sciences, Volume 22, Number 1, pp 3-13.

Konwea, O.A., Adekoya, K.A., and Egwuatu, O.P., (2021). Geotechnical Investigation of the Proposed Dam site at Kajola village, Ile-Ife, Southwestern Nigeria. Zibeline International Publishers, pp 28-33.

Leulalem, S.B., Kifle W. and T.Nata (2016). Geological and Geotechnical Investigations of Axum Dam Site, Tigray, Northern Ethiopia. Addis Ababa Memoir No.6, pp 32-37.

Ntekim, E.E., (2018). Geochemical Characterization of Groundwaters in Adamawa State, North-Eastern Nigeria. Bagale Journal of Pure and Applied Sciences. Vol. 1, No. 1, pp 55-62.

Mahmut, S., Aysel, S., and Selcuk, A., (2020). Determination of Geological Structures by Geophysical and Geotechnical Techniques in Kirklartepe Dam Site, Turkey. Journal of Applied Geophysics, Volume182, pp 236-249.

Perloff, W.H., and Baron, W. (2016). Soil mechanics: Principles and Application. Ronald Press Co., Technology and engineering-745 pp.

Sabinus, I.I., Kalu, K.I., Johnbosco, E. O., Kingsley, O.E., and Ubentu, B.O., (2023). Geoelectrical Investigation of a Proposed Dam Site in a Sedimentary Terrain: Case Study of Aba River at Amapu-Ideobia, Akanu Ngwa, Southeastern Nigeria. International Journal of Geosciences, Volume 4, Number 10, pp 82-91.

Varoujan, K.S., Nasrat, A., and Nadhir, A.A., (2019). Role of Geological Investigation for Dam Siting: Mosul Dam a Case Study. Springer Nature, Volume 38, pp 2085-2095.

Yashas. S. R, Harish. S. N, and Muralidhara. (2016). Effect of California Bearing Ratio on the Properties of Soil, American Journal of Engineering Research (AJER) Volume-5, Issue-4, pp-28-37.

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