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Phytoplankton as Water Quality Indicators In Kano River, Kano State Nigeria

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Abstract
In respect with increasing pollution and subsequent algal growth in River waters, study on algal flora of Kano River was conducted between October 2014 and September 2015 based on anthropogenic activities. Five stations were selected during the process sampled and examined for water physico-chemistry and phytoplankton community structure using basic statistical measurement of diversity indices to characterize the flora of the River. Parameters were examined using established procedure. The results obtained were in the following ranges: conductivity (93.57±61.28±22.10), pH (7.29±0.77-6.96±0.26), Temperature (25.83±4.36-24.53±4.23), Transparency (142.08±77.31-52.11±8.40), DO (6.57±2.75-4.67±2.03), BOD_5 (3.30±1.962.16±1.59), Nitrate (2.80±1.64-1.61±1.23) and Phosphate (2.74±1.59-1.85±1.37). A total of 49 species of Phytoplankton characteristics of water samples from the River revealed varying levels of pollutions. The algae identified at the sites selected belong to the following classes; 22 Bacillariophyceae (44.89%), > 13 Chlorophyceae (26.53%), > 9 Cyanophyceae (18.37%), > 3 Euglenophyceae (6.12%) and lastly > 2 Dinophyceae (4.08%). Meanwhile, Ankistrosdesmus falctus, Chlamydomonas Oscillatoria, Phormidium, Pandorina, Chlorella, Euglena, Phacus, Gomphonema, Navicula, Nizschia, Cyclotella meneghiniana, Synedra ulna, and Melosira granulate are some of the pollution indicating algal species found. However, the water quality indices of the seasons were determined using appropriate statistical methods to assess the tropical status of the River water. Pollution status was determined using organic pollution index by Palmer's pollution index (1969). Shannon-Wiener Index, Evenness Index, showed high phytoplankton composition and abundance during wet season than the dry season. The results from this study showed that the water body is impacted with various anthropogenic activities from the inhabitants coupled with natural mineralization, which facilitated fluctuation of phytoplankton abundance and physicochemical parameters. It is therefore recommended that uncontrolled discharge of agrochemicals around the Dam through irrigation and other human activities should be controlled in order to curtail degradation of the aquatic biota over a period of time.

Keywords*: Phytoplankton, Physicochemical Parameters, Water Quality, Seasonal Variation, Kano River*

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I. Introduction

Humanity either survives or collapses by the quality of water available, assessable and consumable. Water quality therefore becomes an important focal point that requires holistic evaluation in view of its importance to human existence Okechukwu (2009). The most vital requirement after oxygen, as its constant supply is needed to replenish the fluids lost through normal physiological activities such as respiration, perspiration and urination (Shalom *et al.* 2011). Plankton is defined as a collective term used to describe all those organisms whose power of movement are not sufficient to prevent them from being moved by water current (Hosetti and Kumar (2002). Water bodies are known to support a wide array of aquatic organisms which include phytoplankton/algae, zooplankton, nektonic and other variety of small species substantially floating on the water Hester. The quantity and types of such organisms depend on the water quality, especially on physical and chemical qualities and the characteristics of the environment (0dukoya *et al.* 2013; Odukoya 2015). Water quality affects the abundance, species composition, stability, productivity, and physiological condition of indigenous populations of aquatic organisms (Andrew, 2012).

The drainage basin of a river (including its tributaries) is generally shared by several kinds of aquatic ecosystems which may be physically separated but are usually linked together by hydrological cycle (Onyema and Popoola, 2013). These systems require close monitoring and evaluation like from industries that are dumping their effluents into the rivers, thereby polluting them severely (Onyema *et al.,* 2003).

II. Materials And Methods

Study Area

Kano state is located between latitude 10° 30' to 12° 40' and longitude 7° 40' and 9° 30' E, climate is classified as tropical dry and wet type. Kano River is located on Lat.11°50'45" N and Long.8°30'21" E (Getamap 2012). The River is about 58.80 km in length from Tiga dam discharge outlet. Studies were carried out in the upper part of Kano near Tiga dam discharge outlet, the catchment area of the river down to the lower region a confluence point with Challawa, in between which is a dendrites of various mid-streams designated sites.

Site A: This is in the upper parts of the river, situated close to the dam about 50 meters from the main discharge outlet. It is situated close the hydroelectric power project currently under construction in the area. The water is clear and relatively quiet.

Site B: is at the confluence point between Kano and Challawa River at a village called Tamburawa. The location is about 30meters from the 'Tamburawa overhead bridge'. Agricultural activities and some fishing takes place here (although to a lesser degree). The water characteristics show a clear distinction between the Challawa and Kano rivers as the former is contaminated with industrial effluents from the Challawa industrial estate while the latter have fairly normal water color of brownish appearance.

Site C: This is located at Danga village of Kura local government area. The catchment is used for fishing, sand dredging and ferrying by local canoes. Farming activity of sugar cane, onions and pepper are prevalent in addition to laundries. Water characteristics are relatively better than Site B as the effect of effluents become reduced downstream. However the site is located at about 10km distance away from Site B.

Site D: this is located in Wudil town about 200 meters from the Kano Maiduguri overhead bridge and the characteristic activity here includes farming of crops like maize, sugar cane, garden egg, carrots, lettuce etc. The water is brownish in colour. A little downstream, sand dredging happens making the much less transparent.

Site E: This is located about 1000meters from D and it is where the inlet from Wudil main abattoir is situated. Moreover, waste water from Dorawar Dan Nana, Yan Daudu all drained into it. Characteristic foul smell is found here. Water color is dark and movement is slow from the inflow here. Evidence of organic contamination i.e. greenish growth indicating blooms is seen here. Therefore, the sampling sites were grouped as upstream (sites A and B), mid stream (site C) and downstream (sites D and E) according to Berger *et al.* (2017). Each sampling site was further divided into three sub-sites. Furthermore, the status of these stations is unstable as the nature of the activities varies between the months. This is to say, the numbers of human activities are many in some months and lessen in others.

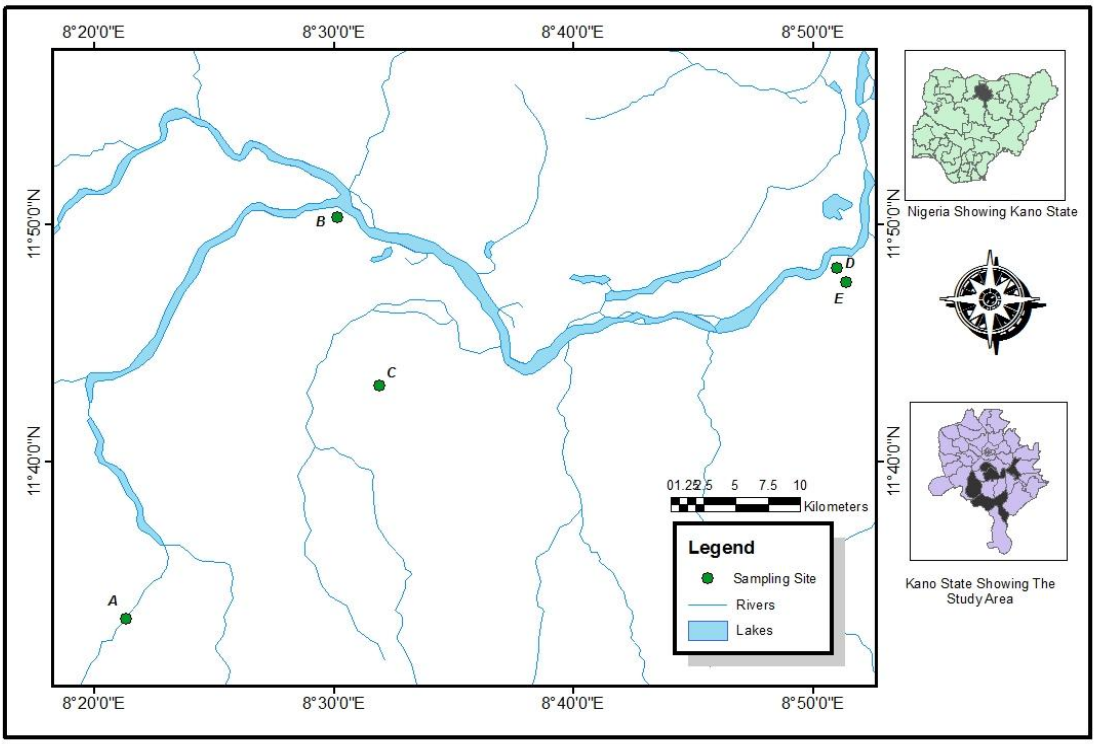

Figure 1: Map of Kano River Showing the Sampling Sites (Cartography Lab. Geography Department, Bayero University Kano)

Sample Collections

Physico-chemical Parameters

The procedures given by Ademoroti, (1996) and Quintana *et al.*(1998), dip-in pH meter manual, Stirling (1985) In Adeyemi (2012) were followed during samples collection for the following physical and chemical parameters: Dissolved Oxygen (DO), BOD_5, Electrical conductivity (E.C), pH, Transparency from the five sampling Sites namely A- (Tiga out-let), B- Tamburawa (In-take), C- Danga river (Dan hassan), D and E (Wudil river) on monthly basis for the 12 calendar month period of the survey.

Biological Parameters

With the aid of a planktonic net of 55µm diameter with a collecting bottle of 50cm capacity attached at the base, water samples were collected between the hours of 7:00 and 12:00 every month from three different points on the stream namely the Upper stream, Middle stream and Lower stream and labeled Stations A, B and C, respectively, from October 2014 to September 2015. These samples were preserved with 5% formaldehyde and Lugol's iodine for zooplankton and phytoplankton respectively at the site before they were taken to the Biological Science Laboratory, Kano University of Science and Technology Wudil for analyses.

Sample Analyses

Analysis of Physico-Chemical Parameters

Temperature: Water temperature was determined in-situ using mercury in-glass thermometer with range of 0° – 36°C. After calibration, the thermometer was immersed directly into the water for 5 minutes until a steady temperature measure was obtained (Adeyemi, 2012).

Transparency: Transparency was determined using secchi disc with four graduant of alternate black and white coloration on the upper surface and a long rope at the centre. Measurement was achieved by lowering the disc into the water until it disappeared. At this point, the measurement was taken. The rope was released further down and then pulled up slowly until the disc re-surface, the point was also measured. Now the difference between these measurements was recorded. (Stirling, 1985): In Adeyemi (2012).

Dissolved Oxygen: This was determined using 200 model dissolved oxygen meter and procedure followed was described by Ademoroti (1996), wherein zero oxygen solution was prepared by dissolving 2g of sodium sulphate in 100ml of water. This was allowed to stand for 2 to 5 minutes. The calibration key was pressed and then the meter proof was inserted into the prepared solution and was allowed to stand for 30 seconds to calibrate the meter to zero (0). Sample water was poured in to beaker up to 50ml mark, the calibrated meter proof was then inserted into the sample, this was allowed to stand for a minute and then final reading was recorded in mg/l.

Biochemical Oxygen Demand: The water sampled in a 250ml bottle as in above, was incubated at a room temperature for five days. The above methodology was followed to determine dissolved oxygen on the fifth day. Finally BOD_5 was obtained by subtracting the final result from the initial DO as far below;
BOD_5 (mg/l) = Initial DO - Final DO.

Electrical Conductivity: The conductivity of the Kano river water was measured using a jenway conductivity meter model 4010. During the process, a 250ml capacity bottle from each site water sample was taken to the laboratory; the meter was calibrated and allowed to stabilize for about 15minute in a buffer solution of potassium hydroxide (0.001m). The electrode was washed with distilled water and dried with cotton wool. The electrode made from platinum plates was dipped into the sampled water. Each time after dipping, the electrode was washed with distilled water and dried with fresh cotton wool. Conductivity of a solution was defined by Golterman *et al.* (1987) as a measure of its capacity to convey electric current.

pH: pH values were determined using dip-in mobile battery operated pH meter. During the process, the meter was calibrated using pH 4, pH7 and pH10 buffer solutions. The sample was poured into 50ml beaker and the electrode meter was dipped in for a minute. Readings were taken directly from the meter.

III. Results

Biological Parameters

A total of 49 species were identified in this study belonging to five (5) taxa in which *Bacillariophyta* had the highest percentage of 44.89% with 22 genera, followed by *Chlorophyta* with 26. 53% (13), *Cyanophyta* 18.37% (9), *Euglenophyta* 6.12 (3) and the least was *Dinophyta* with 4.08% (2) Table 1.

Table1: Phytoplankton Occurrence, Distribution and Relative Abundance at the Sampling Sites (October 2014- September 2015)

S/N	Taxa	SITES A	B	C	D	E	Total for all sites (org/l)	Frequency for total (%)
	Cyanophyceae (Blue- green algae)							
1	*Aphanizomena flos- aquae*	6.67	-	24.44	20.37	16.29	67.77	80
2	*Cylindrospermopsis*	2.59	20.37	24.44	8.15	8.15	93.69	100
3	*Lyngbia*	-	24.44	-	8.14	-	32.59	40
4	*Microcystis aeroginosa*	24.44	8.15	12.22	28.52	4.07	77.41	100
5	*Oscillatoria limnosa*	28.52	12.22	12.22	28.52	20.37	101.85	100
6	*Oscillatoria limnetica*	8.15	16.29	-	28.52	8.15	61.11	80
7	*Gloetrichia* sp.	16.29	-	12.22	-	-	28.51	40
8	*Hyalodiscus* sp.	28.52	-	8.15	12.22	4.07	52.96	80
9	*Tolypothrix* sp.	-	8.15	-	8.15	8.15	24.45	60
	Chlorophyceae(Green algae)							
10	*Ankistrodesmus acicularis*	-	-	-	4.07	4.07	8.14	40
11	*Chlamydomonas* sp.	-	12.22	4.07	-	-	16.29	40
12	*Chlorella* sp.	-	24.44	-	4.07	-	28.51	40
13	*Cosmarium botrytis*	8.15	8.15	8.15	28.52	4.07	77.41	100
14	*Dictyosphaerium*	8.15	36.67	-	40.74	-	48.89	60
15	*Eudorina* sp.	28.52	24.44	8.15	16.29	28.52	105.91	100
16	*Oocystis*	-	-	-	-	8.15	8.15	20
17	*Pandorina*	-	8.15	-	4.07	-	12.22	40

18	*Scenedesmus quadricauda*	24.44	-	8.15	16.29	-	77.59	60
19	*Scenedesmus obtusus*	16.29	-	12.22	-	12.22	40.73	60
20	*Spirogyra*	36.67	36.67	32.59	44.81	44.81	195.55	100
21	*Stigeoclonium tenue*	-	-	20.37	4.07	-	24.44	40
22	*Volvox*	-	-	8.15	4.07	8.15	20.37	60

Cont. of Table1: Phytoplankton Occurrence, Distribution and Relative Abundance at the Sampling Sites (October 2014- September 2015)

S/N	Taxa	SITES						
		A	B	C	D	E	Total for all sites (org/l)	Frequency for total (%)
	Bacillariophyceae(Diatoms)							
23	*Aulacoseira grannulata*	8.15	8.15	8.15	-	-	24.45	60
24	*Cymbella lanceolata*	8.15	-	12.22	-	8.15	28.52	60
25	*Diatoma* sp.	12.22	-	8.15	8.15	16.29	44.81	80
26	*Fragillaria crotonesis*	4.07	52.96	-	4.07	4.07	65.17	80
27	*Gomphonema* sp.	28.52	32.59	8.15	12.22	48.89	130.37	100
28	*Gyrosigma* sp.	12.22	-	-	4.07	8.15	24.44	60
29	*Navicula gracilis*	20.37	20.37	8.15	8.15	16.29	73.33	100
30	*Navicula viridis*	4.07	28.52	12.22	12.22	8.15	65.18	100
31	*Nizschia acicularis*	-	-	4.07	-	4.07	8.14	40
32	*Nizschia cryptocepahli*	-	-	8.15	-	-	8.15	20
33	*Nitzschia palea*	-	-	20.37	-	-	20.37	20
34	*Nitzschia sigmoidae*	16.29	-	-	-	-	16.29	20
35	*Pseudo nitzschia*	20.37	20.37	36.67	8.15	24.44	110.00	100
36	*Melosira grannulata*	20.37	8.15	8.15	8.15	16.29	61.11	100
37	*Melosira variance*	32.59	48.89	8.15	12.22	48.89	150.74	100
38	*Stephanodiscus invisitatus*	28.52	44.81	-	8.15	4.07	85.55	80
39	*Tabellaria flos- aquae*	24.44	12.22	-	-	-	36.66	40
40	*Tabellaria flocculosa*	12.22	28.52	-	-	-	40.74	40
41	*Asterionella* sp.	8.15	4.07	8.15	4.07	-	24.44	80
42	*Surierella* sp.		36.67	24.44	32.59	48.88	142.58	100
43	*Synedra ulna*	9.26	-	-	-	-	9.26	20
44	*Synedra acus*	28.52	-	16.29	-	12.22	57.03	60

Cont. of Table1: Phytoplankton Occurrence, Distribution and Relative Abundance at the Sampling Sites (October 2014- September 2015)

S/N	Taxa	SITES						
		A	B	C	D	E	Total for all sites (org/l)	Frequency for total (%)
	Dinophyceae(Dinoflagellates) ***kkkllkkk***							
45	*Ceratium* sp.	8.15	8.15	8.15	28.52	4.07	57.04	100
46	*Peridinium* sp.	-	-	24.44	8.15	36.67	69.26	60
	Euglenophyceae(Euglenoids)							
47	*Euglena* sp.	-	4.07	4.07	16.29	4.07	28.50	80
48	*Phacus* sp.	-	-	4.07	4.07	-	8.14	40
49	*Trachelomonas* sp.	-	44.81	4.07	4.07	8.15	61.1	80

Total count	**544.05**	**643.68**	**431.82**	**492.9**	**501.05**	**2613.5**	
Mean	**2.59**	**4.07**	**4.07**	**4.07**	**4.07**	**8.14**	**80**

Key: - no organism found

Analysis of phytoplankton community structure with respect to pollution status of Kano River using Palmer Pollution Index (P.P.I) revealed a total of 12 genera out of the 49 species identified. The values of P.P.I when added were 32 which is higher than 20 used by Palmer (1961) for assessing the level of organic pollution in limnological research.

Temporal variation with respect to P.P.I revealed that wet season had 18 score while 14 was recorded in dry season. Table2.

Table 2: Mean Monthly Variations in Physico-Chemical Parameters and Plankton Distribution at the Sampling Sites (October 2014- September 2015)

Sites	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total mean
Temperature (°C)	23.18	23.20	20.80	19.80	20.04	21.50	23.08	24.20	24.24	25.20	25.98	27.84	21.76
PH	7.30	7.17	7.05	7.30	7.47	7.00	7.18	7.16	6.54	6.80	7.03	7.06	7.09
E.C (µS/cm)	113.18	106.20	54.38	60.06	73.00	94.00	82.36	90.66	75.80	71.46	73.90	67.74	80.15
Transparency (cm)	44.20	53.00	50.30	53.00	30.50	38.50	37.50	38.50	56.00	55.30	58.00	58.20	47.75
DO (mg/l)	5.46	4.03	6.69	7.99	6.98	6.26	4.62	5.80	2.06	3.50	2.63	1.50	4.27
BOD_5 (mg/l)	1.85	1.22	0.69	3.12	3.60	2.26	0.98	2.52	0.96	2.20	1.28	0.54	1.77
Nitrate (mg/l)	3.99	3.02	2.51	1.34	2.38	1.87	1.42	2.27	1.66	0.03	2.37	0.29	1.93
Phosphate (mg/l)	2.38	5.27	3.04	2.48	3.29	2.66	1.60	2.18	1.59	0.75	1.58	0.43	2.27
Phytoplankton Density (Org/l)	109.99	138.52	146.66	452.21	211.85	419.62	631.47	407.39	317.77	171.11	338.14	513.32	321.50

Table 3: Mean Monthly (± SD) Values of Plankton Conditions of the study stations, in Kano River during the Period Oct. 2014–Sep. 2015

Months	Phytoplanktons (org/l)
Dry	
Dec	7.20 ± 1.19^{a}
Jan	25.20 ± 15.48^{b}
Feb	10.40 ± 5.22^{ac}
Mar	20.80 ± 9.36^{bc}
Apr	27.20 ± 11.37^{b}
May	20.00 ± 18.21^{bc}
Wet	
Jun	15.60 ± 4.83^{bc}
Jul	8.40 ± 2.07^{ac}
Aug	16.60 ± 5.50^{bc}
Sep	25.00 ± 11.34^{b}
Oct	5.40 ± 3.21^{a}
Nov	6.80 ± 5.36^{a}

Table 5: Mean Monthly (± SD) Values of Plankton Conditions of the study stations, in Kano River during the Period Oct. 2014–Sep. 2015

Months	Phytoplankton (org/l)
Oct	5.40±3.21[a]
Nov	6.80±5.36[a]
Dec	7.20±1.19[a]
Jan	25.20±15.48[b]
Feb	10.40±5.22[ac]
Mar	20.80±9.36[bc]
Apr	27.20±11.37[b]
May	20.00±18.21[bc]
Jun	15.60±4.83[bc]
Jul	8.40±2.07[ac]
Aug	16.60±5.50[bc]
Sep	25.00±11.34[b]
LSD	12.54

Spatial variation indicated that mid stream (site B) had the highest P.P.I value of 16 score, followed by the upstream (site A) with 9 and 7was recorded at the downstream (site C) table 3.

Table 6: Mean (± SD) Values of Plankton (Biological) Conditions of the Stations, in Kano River During the Period of Study (Oct. 2014-Sep. 2015)

Sites	Phytoplankton (org/l)
A	19.58±15.00[a]
B	14.17±11.68[a]
C	13.17±10.24[a]
D	14.92±11.98[a]
E	16.75±10.06[a]
LSD	-

Mean ±standard deviation with the same letter are not significantly different from each other (Least Significant Difference P<0.05

IV. Discussion

Palmer pollution Index of 32 was obtained on the phytoplankton indicator organisms during this study. It revealed that Kano River fall within the category of being high of organic pollution due to the identification of 12 pollution relevant genera such as ; Microcystis sp., Oscillatoria sp., Ankistrosdesmus sp., Chlamydomonas sp., Nitzschia sp., Melosira sp., Synedra sp., Euglena sp. and Phacus Sp. this observation is in consistent with the work of Muhammad and Saminu (2012) in Salanta River of Kano State. The high pollution tolerance genera identified were favoured by the environmental condition during the study period as reported by Nosrati and Eeckhout (2012), who described phytoplankton as rapid detectors of water quality due to their quick response to environmental variables and toxic substances which accumulates intoxicate the entire food chain. Diatoms (Navicula, Niztschia, Melosira and Synedra species), had the highest number of pollution indicator Phytoplankton from the study. This could be due to their tolerance of environmental stress caused by anthropogenic activities hence their dominance at all the sampling sites as observed by Mustapha *et al.* (2012a). Diatoms have been reported in the present study followed by Chlorophyta in decreasing order. This observation is in agreement with that of Mustapha *et al.* (2014) in Kano River.

Temporal variation across the months indicated that 16 P.P.I score was obtained in wet season while 14score in the dry season. The highest values in the wet season could be due to the run -off into the River from its tributaries and near- by farm lands that enrich the water and possibly led to high phytoplankton growth. Spatial variation in Kano River revealed high P.P.I value at mid stream (site B) compared to upper and down streams. This variation may perhaps be due to difference in the morphometry of the sampling sites. The mid stream (site B) is characterized by agricultural activities and industrial effluents from Challawa River which might have accelerated the growth of pollution tolerant phytoplankton. The above observation is in consistence with the works of Ibrahim (2009) and Imam (2012) in Challawa and Jakara River respectively. Mustapha *et al*. (2012b) also observed that in water bodies where domestic and agricultural activities persist pollution is accelerated through the growth of Chlorophyta and Cyanophyta. During this stud the bloom producing algal genera revealed include; Microcystis and Oscillatoria spcies. This demonstrates the gradual decrease in water quality of Kano River as observed by Mustapha *et al*. (2014).

V. Conclusion

The study revealed that due to obvious agricultural and industrial activities around the river and its tributaries, the health of the water body is impaired with pollution tolerant phytoplankton genera (12 genera out of the 49) indicating organic pollution in the River. This is therefore recommended that relevant anthropogenic activities should encourage continuous bio monitoring of in land water bodies with view of tracking future adverse environmental challenges.

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