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Kinetic Constant, Blabber of Natural Waters Pollution. Case of Lukaya River in Democratic Republic of Congo

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ABSTRACT

In this short paper a study of LUKAYA River pollution has been undertaken by means of the determination of biochemical demand in oxygen kinetic constant (BDO). The values of this constant have shown that the water of LUKAYA River is unsuitable to drink without treatment. The electrical conductivity values variations testify a great contamination and a strong mineral kingdom of the milieu. Turbidity values evince the pollution confirmed by the above mentioned parameters (BDO kinetic constant and conductivity).

Keywords: *LUKAYA River, Kinetic Constant, Pollution, Velocity of pollution, Streeter and Phelps models.*

INTRODUCTION

The essay of BDO is a measure of the biodegradable organic carbon, and, in certain conditions, reduced nitrogenous forms in the impaired water. The CDO is a measure of the total organic carbon, except certain aromatic compounds such as the benzene, which are not completely oxidized in the work conditions[1,2,3]. The CDO is a chemical reaction of oxydo-reduction; others reduced compounds, the sulphides, the sulphites, the Fe^{2+} ions for example, can also be oxidized and so accounted as CDO. The TOC allows the measure of the totality of carbon after transformation in CO_2.

It is needful to eliminate the mineral forms (CO_2 , HCO_3^- , etc) before the analysis or to correct by calculation the analytic result. The TDO measures both the organic carbon and the reduced forms of nitrogen and sulphur. The biochemical demand in oxygen is the oxygen quantity needful for the alive microorganisms to assure the oxidation and the stabilization of organic matters present in the impaired water. Conventionally, the BDO is the value obtained after five days of incubation, BDO_5.

The normalized essay foresees a microbial sowing by means of domestic impaired water, river water or a station effluent, and incubation at 20° C.

The biochemical reaction occurring in the BDO flask is identical at all reactions relative to aerobic fermentation and is happening in two distinct successive phases. At the beginning, the organic matter is used by the microorganisms to assure their energetic needs and their growth [4,5].

It ensues oxygen consumption and an increase of microbial population. After disappearing of initial organic matters, the microorganisms continue to consume the oxygen in order to assure the self-oxidation of the cellular content or the needs of their endogen metabolism [6,7]. After complete oxidation of biomass it still remains a no biodegradable residue and the process is achieved. This step defines the ultimate BDO. The BDO is an oxidation in two phases.

The elimination and the oxidation of organic matters present in the impaired water are generally complete after 18-36 hours of incubation (1st phase). The oxidation of the biomass entails more than 20 days (2nd phase)

The reaction velocity of first phase, called assimilation phase is 10-20 times more than the velocity of the endogen oxidation. Note that the average kinetic constant of BDO, **k**, will vary considerably as function of the quantity and the nature of the organic matters present in water because the BDO consists in two distinct and continued phases having different reactions velocities.

MATERIALS AND METHODS

2.1. Materials

- pH-meter CIFEC ,568810
- digital turbidimeter, Lovibond , turbicheck, SN11/30170, tintometer GmbH
- BDO reactor (BSB-controller modell 620 T)
- Conductimeter WTW 82362 Welhein cond 3305
- Scale Mettler AE100
- Chronometer ,distillate water and magnetic stirrer have been used apart the burettes and reactants such as NaOH, concentrated H_2SO_4 , stantard solution of dichromate of potassium 0,25 N , standard solution of $FeSO_4$,Ammonium solution 0,125 N, $HgSO_4$ cristals.

2.2. Target Milieu

Briefly LUKAYA River has its origin in Bas Congo Province, it throws itself in N'Djili River in Kinshasa ; it has 50 km of length , 300 km^2 of surface. Two seasons characterize the milieu, the dry season of almost four months (15 May -15 September) and the rainy one of almost eight months. The savanna is the vegetation of the river in which woods and blades are found in typical tropical climate as it is shown in figure 1.

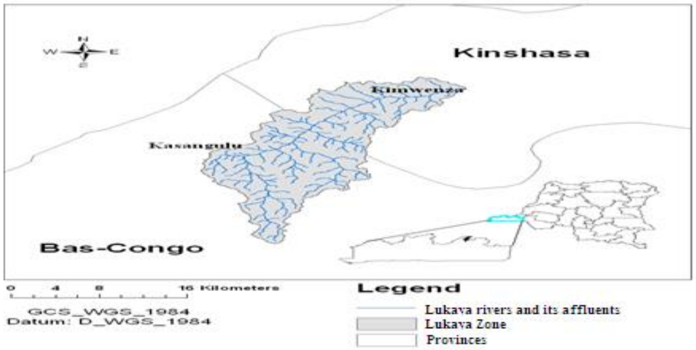


Fig.1. Localization of LUKAYA River and its affluents

2.3. Methods

2.3.1. Sampling

The River water to be analyzed for BDO measures has been taken at almost 1 meter of depth on four sites: BOMUNA (S_1), LIBI (S_2), KIMUENZA (S_3) and Ma Vallée bridge (S_4), and bottled in cleaned polyethylene (100ml) . On each site studied geographical parameters (altitude, latitude, longitude) have been measured by means of GPS Garmir [3,8,9,10]. See for example Ma Vallée Site and Career of KIMWENZA Site shown in figures 2 and 3.

Fig.2. LUKAYA River (Ma Vallée Site)

Fig.3. Career of KIMWENZA and its rejection points on the river.

Conductivity, turbidity, and p^H measures have been carried out immediately in Laboratory. Afterwards the samples have been kept at 4°C -10°C [11] to avoid the microorganisms development for subsequent analysis. Note that the measures of BDO do not take into account the nitrification phenomenon because the carbon is more reactive than nitrogen in presence of oxygen.

2.3.2.Kinetic model of BDO₅

The BDO is usually calculated according to this equation [9,12,13].

$$\frac{dx}{dt} = -Kx \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$$x_t = x_0 . e^{-Kt}$$

$$y = x_t - x_0$$

$$\boxed{y = x_0 \ (1- \ 10^{-kt})} \quad \ldots\ldots\ldots \text{(2)}$$

$$\boxed{y = x_0 \ (1- \ e^{-Kt})} \quad \ldots\ldots\ldots \text{(3)}$$

Where K= 2,3k

y = consumed quantity of oxygen = BDO at time t

x_0 = total quantity of oxygen consumed by the reaction

= ultimate BDO limited at the oxidation of carbon

x_t = remaining BDO at time t

K, k = kinetic constants respectively in neperian system and in decimal system.

$$\frac{dy}{dt} = r = x_0 \ K e^{-Kt} \quad \ldots\ldots\ldots\ldots \text{(4)}$$

r is the velocity of oxygen consumption

$$\ln r = \ln(x_0 K) - Kt$$

$$2{,}3 \log r = 2{,}3 \log(x_0 K) - Kt$$

$$\log r = \log (x_0 K) - \frac{K}{2{,}3} t \quad \ldots\ldots\ldots\ldots \text{(5)}$$

$$\boxed{\log r = \log(x_0 K) - kt} \quad \ldots\ldots\ldots \text{(6)}$$

The equation (6) is our work equation.

k is calculated at 20°C.

The oxygen from photosynthesis has been neglected in comparison with the quantity of the atmosphere oxygen.

The statistical treatment of the results has been carried out by means of Origin 8 program.

RESULTS AND DISCUSSION

According to the values in table1 it can be seen that the temperature varies from 17,5 °C to 25 ,33°C. It has been reported indeed that the variation of temperature is a contamination indication. In general the River temperature variations depend on climatic conditions [7,13,14]. Also in this table it can be observed that p^H varies between 5,71- 7,42 ; the international standards recommend a variation between 5,5-9,2 as acceptable limits in case of surface water . This low acidity of equatorial waters has been confirmed by LUSAMBA et al. [1,3,15].

With respect to the turbidity it varies from 0,65 NTU to 57,79 NTU. Its value accepted by the Health World Organization is 25 NTU [1,14].

The particular accent has been put on the measurement of conductivity as it is shown in the table 2 where it is noted the variation of conductivity as a function of time.

Table 1. Values of temperature, conductivity, p^H and turbidity.

N°	Sites	Geographics coordinates	Temperature (°C)	Electric conductivity (µS/cm)	pH	Turbidity (NTU)
1	Source (TAMPA)	S :4°46' 37,26'' E :15°13'47,52'' Altitude :250 m	23,80	21,60	5,71	0,65
2	REGIDESO factory Intake of KASANGULU	S :4° 35' 57,88'' E :15°10'14,52'' Altitude :270 m	21,60	14,20	6,67	25,95
3	KASANGULU Bridge	S :4° 35' 35,35'' E :15° 10' 6,92'' Altitude :269 m	21,60	16,40	6,66	27,51
4	SGI Bridge	S :4° 34' 54,17'' E :15°11'19,56'' Altitude:300 m	22,00	21,40	6,85	25,99
5	KINGANTOKO	S :4° 31' 25,39'' E :15°13'47,05'' Altitude :310 m	21,50	17,50	7,12	24,40
6	MPEMBELE Site	S : 4° 29' 42,3'' E :15° 15' 14,3'' Altitude: 326 m	17,50	17,50	7,32	27,61
7	Affluent BOMUNA	S : 4° 29' 38,3'' E :15° 15' 19,1'' Altitude: 322 m	24,00	14,70	6,55	26, 68
8	REGIDESO factory Intake (site BOMUNA)	S : 4° 29' 33,6'' E :15° 15' 23,8'' Altitude: 318 m	23,60	16,90	6,97	23,33
9	Affluent LIBI	S : 4° 29' 31'' E :15° 15' 36,6'' Altitude :319 m	25,20	239,00	7,42	57,79
10	REGIDESO factory Intake (KIMWENZA Site)	S : 4° 28' 55,6'' E :15° 16' 19,9'' Altitude :318 m	25,33	18,11	7,03	42,08
11	MA VALLEE Bridge	S : 4° 28' 30,2'' E :15° 16' 41,4'' Altitude :308 m	24,00	18,90	7,02	31,65
12	MELON Bridge	S : 4° 28' 18,1'' E :15° 17' 13,7'' Altitude :300 m	24,60	22,30	7,12	40,28

Table 2. Values of electric conductivity as a function of time.

N°	Time (minutes)	Electric conductivity (µs/cm) Month				
		June 2015	*July 2015*	*August 2015*	*September 2015*	*October 2015*
1	30	50	85	25	40	39
2	60	30	80	50	50	25
3	90	75	90	50	75	45
4	120	75	50	25	72	45
5	150	100	75	125	50	50
6	180	135	175	150	50	75

7	210	200	160	150	160	160
8	240	275	180	215	190	260
9	270	250	180	260	175	250
10	300	150	175	225	125	225
11	330	110	150	175	110	175
12	360	50	125	175	75	100
13	390	75	50	200	75	75
14	420	25	75	50	35	50

The situation can be well seen in figures 4a and 4b where the pollution is undoubtedly evidenced.

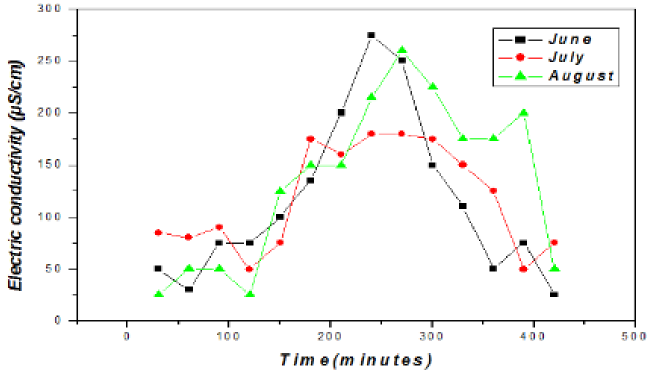


Fig 4a. Electrical conductivity versus time

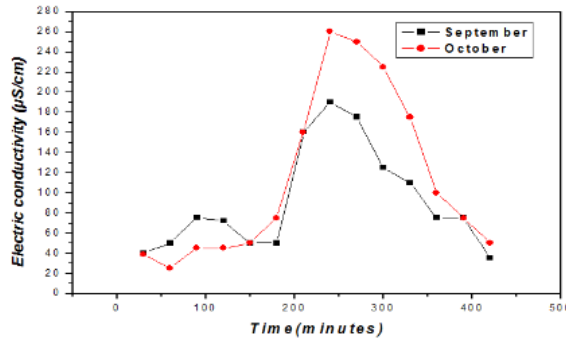


Fig 4b. Electrical conductivity versus time

The table 3 gives the daily consumption of BDO_5 on BOMUNA site.

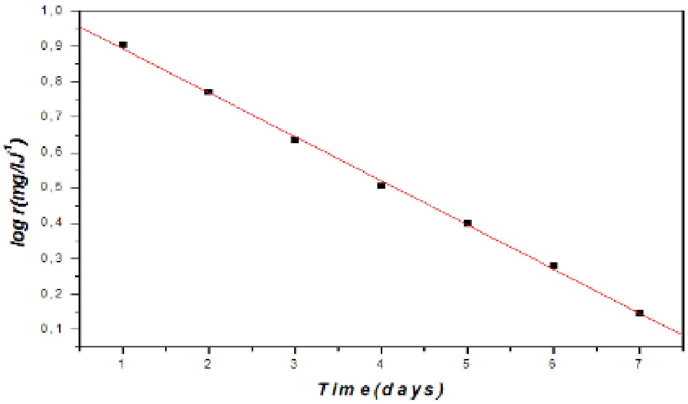
Table 3. Daily consumption of BDO_5 (BOMUNA site).

Time (days)	y : Consumed Oxygen quantity or BDO at time t (mg/l)	r : Daily consumption (mg/l)	log r
0	0	-	-
1	8	8,000	0,903
2	10,500	5,900	0,771
3	14,800	4,300	0,634
4	18,000	3,200	0,505
5	20,500	2,500	0,398
6	21,600	1,900	0,279
7	23,000	1,400	0,146

Table 4: Daily consumption of BDO_5 (LIBI site).

Time (days)	y : Consumed Oxygen quantity or BDO at time t (mg/l)	r : Daily consumption (mg/l)	log r
0	0	-	-
1	11,000	11,000	1,041
2	18,100	7,100	0,851
3	22,300	4,200	0,690
4	25,800	3,500	0,544
5	28,100	2,300	0,362
6	29,800	1,700	0,230
7	30,900	1,100	0,041

When log r is correlated to time expressed in days the kinetic constant (k) is found equal to 0,125 d^{-1} as it can be observed in figure 5.



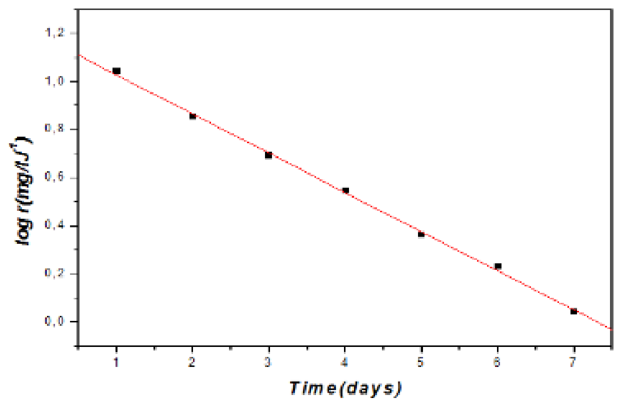


Fig 5. log r versus time

Fig.6. log r versus time

Table 5. Daily consumption of BDO_5 (KIMWENZA site)

Time (days)	y : Consumed Oxygen quantity or BDO at time t (mg/l)	r : Daily consumption (mg/l)	log r (mg/l)
0	0,000	-	-
1	9,000	9,000	0,954
2	15,500	6,500	0,813
3	19,900	4,400	0,644
4	23,400	3,500	0,544
5	25,900	2,500	0,395
6	27,500	1,600	0,204
7	28,900	1,400	0,146

Table 6. Daily consumption of BDO_5 (Ma Vallée Bridge site).

Time (days)	y : Consumed Oxygen quantity or BDO at time t (mg/l)	r : Daily consumption (mg/l)	log r
0	0	-	-
1	10	10	1
2	17	7	0,845
3	21,9	4,9	0,690
4	25,2	3,3	0,519
5	27,45	2,25	0,352
6	29,09	1,6	0,204
7	30,15	1,1	0,041

The following values have been obtained according to this figure 5:

x_o= 36,307mg/l; K= 0,287d^{-1}; x_oK= 10, 420 $\frac{mg}{l}$ d^{-1}; k= 0,125d^{-1}.

It has been reported that when 0,12 ≤ k ≤ 0,22 the situation reveals the river contaminated by an effluent with a strong bacterial charge [13,16,17].

In some reference when 0,15 ≤k≤ 0,28 the polluted water is not treated. The treat effluent of high quality gives 0,06 ≤ k ≤0,10. For river water little bit polluted kinetic constant should range 0,04 ≤ k ≤ 0,08.

The table 4 is relative to daily consumption of BDO_5 on LIBI site.

This table 4 gives rise to the figure 6 showing thus the relation between log r and time.

The following parameters have been calculated according to this figure 6.

x_o= 41,30mg/l; K= 0,375d^{-1}; x_oK= 15, 488 $\frac{mg}{l}$ d^{-1}; k= 0,163d^{-1}.

The table 5 gives the daily consumption of BDO_5 on KIMWENZA site.

In this case log r as a function of time gives k = 0,139 l^{-1} as it has observed in figure 7.

Here are the parameters values:

x_o= 37,919mg/l; K= 0,320d^{-1}; x_oK= 12, 134 $\frac{mg}{l}$ d^{-1}; k= 0,139d^{-1}.

Finally the table 6 concerns the sample of Ma Vallée bridge.

The following parameters in this last case have been calculated:

x_o= 39,432mg/l; K= 0,370d^{-1}; x_oK= 14, 590 $\frac{mg}{l}$ d^{-1}; k= 0,161d^{-1}.

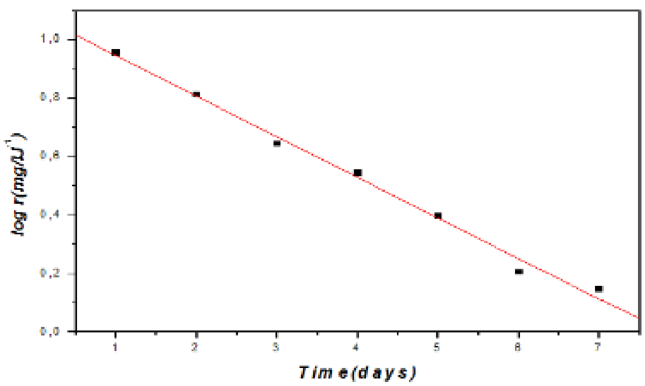


Fig.7. log r versus time

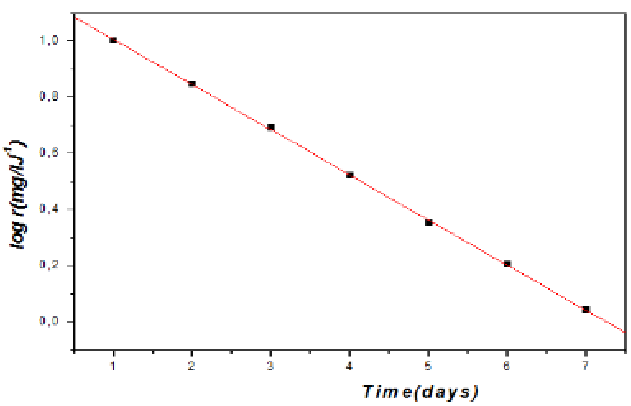


Fig.8. log r versus time

CONCLUSION

The measurements of p^H, turbidity , temperature , conductivity , carried out on Lukaya River from TAMPA (source) until Melon bridge show the river pollution [3,10,18].

Also the kinetic constants of BDO_5 determined on four sites of the River confirm the River pollution and consequently its water is unsuitable for consumption. [1,3,19,20].

To better the diagnostic of characterization of waters pollution one should add to Streeter and Phelps method the physical tests, the chemical tests and microbiological tests.

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