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Effects of Cassava Wastewater on the Quality of Receiving Water Body Intended for Fish Farming

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Aim: The goal of the study is to determine the suitability of a pond into which cassava mill wastewater is discharged for fish farming. The pond which is located adjacent the Faculty of Engineering of the Delta State University, Oleh Campus is currently being proposed for acquisition by the Faculty for the project.
Methodology: A total of 13 physicochemical parameters were analysed from samples collected at four different points around the pond. The parameters investigated were pH, CN, BOD, COD, DO, turbidity, conductivity, hardness, Pb^{2+}, Hg^{2+} and Fe^{2+}. The TSS, TDS, DO, total hardness were determined by the UV absorption spectrophotometer at 220 and the metal ions at 420nm respectively; while the Winkler's titrimetric method was used to determine the COD and BOD. The pH, conductivity and turbidity were determined using the pH meter, conductivity meter and turbidity meter respectively.
Results: The average cyanide content at the discharge point over the four weeks experimental period was 39.0±1.69 with a highly significant effect (p=0.042) and the lowest value of 3.8±0.01 mg/l was recorded 10 metres downstream of the discharge point. The COD, BOD, TDS and TSS at the discharge point were 1236±0.63 mg/l, 430.7±0.53 mg/l, 975±0.90 mg/l and 4030±9.26 mg/l respectively; while the Pb^{2+} and Hg^{2+} were higher at the sample point close to a refuse dump. Values recorded for all the tested parameters were far higher than that recommended for water

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bodies suitable for fish farming.
Conclusion: The pond cannot be used for the intended project at its present form, it could be considered for use however, if all sources of pollution are stopped with proper remediation.

Keywords: Cassava wastewater; water body; fish farming; physicochemical parameters; remediation, environment.

1. INTRODUCTION

Cassava (*Mannihot esculenta*) a tuberous, woody perennial plant of the spurge family (euphorbiaceane) had become a staple food in most developing countries of sub-Saharan Africa as well as most Asia countries [1,2]. Cultivation of cassava in Nigeria is carried out mostly on subsistence level generally by the low income group in the villages. The conversion of cassava tubers to edible form involves series of processing steps [3]. These processing steps include peeling of the tubers, washing of the peeled tubers, grating of the tubers into paste, dewatering or squeezing of the paste, drying and frying to produce gari, a staple delicacy for both poor and rich.

The steps mentioned above especially washing of the tubers and paste squeezing generate large quantities of wastewater [4]. The wastewater from washing of the tubers contains large amount of inert materials with low chemical oxygen demand (COD) while that obtained from the de-watering of the grated paste have high contaminating load of biological oxygen demand (BOD) and COD as well as high cyanide content [4,5]. It had been stated that this cassava processing step consumes about 23m^3 of water per ton of cassava with the generation of about 180kg of COD per ton of roots [4,6]. As a result of the high BOD, COD and cyanide concentration in the discharged wastewater, it poses grave danger to flora, fauna and the environment in general.

Cassava processing in Nigeria's Niger Delta is done majorly by local farmers who do not have the technology to adequately manage the cassava effluent wastewater; as a result the wastewater generated is discharged freely into open channels, gutters, streams, ponds and waterways. This indiscriminate discharge of cassava wastewater impacts negatively on the environment as its organic content may contaminate groundwater supply and cause eutrophication of surface water [3,7]. The cyanide in cassava that accompanies the discharged effluent water during processing poses additional environmental pollution problem. The cyanide which may be present in simple and complex form with varying degrees of solubility, toxicity and stability are subject to rapid breakdown with possible effects on human health and the environment [8].

Cyanide is usually present in cassava wastewater effluent as hydrocyanic acid and the unbroken down cyanogenic glycoside. Cyanogenic glycosides are glycoside compounds containing a moiety linked to a non-glycon entity from which it can be separated by hydrolysis [5,9]. Cyanogenic glycoside themselves are not toxic and harmful, but they hydrolyze to form toxic and harmful hydrocyanic acids [10,11]. In addition to the wastewater effluent discharged directly into streams and bodies of water, cassava peels as well as unrecoverable starch not properly disposed also constitute grave danger to the environment. These by-products especially the peels contain high concentration of cyanogenic glycosides and free cyanide which is degraded by rain water or atmospheric dew when disposed on soil and leached into the soil thereby causing some changes in soil properties such as total solid, total organic carbon, nitrogen and phosphorus [4]. The peels when discharged directly into streams and rivers as done by the local farmers are easily hydrolyzed forming lethal hydrocyanic acid and hydrogen cyanide with its attendant effects on aquatic life and humans who consume such aquatic life. Degraded cassava peels also generate objectionable odour and promotes the conducive, stagnant environment favourable for the breeding of flies and insects such as mosquitoes.

Many, if not all the local cassava processing outlets in villages of the Niger Delta Area do not consider cassava effluent disposal a problem, since the impact of such waste on the environment is not immediately discernable. This gap in knowledge according to FAO [12] is as a result of lack of proper understanding of the relationship between cost effective ways of treating cassava wastewater as well as value added advantage of treating cassava waste products. Despite this ignorance about cassava wastewater treatment by local farmers, various research works have been directed towards cassava effluent treatment systems capable of treating wastes and converting some of the waste products to useful products [3,13,14,15, 16,17]. In the present study, the physicochemical parameters of a stagnant body of water receiving cassava wastewater is analysed at various points to determine the effect of the waste on the water quality and the suitability of the water body for fish farming.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was carried out at a local cassava processing mill located upstream a big burrow pit (pond) into which the cassava mill's wastewater and other effluents are channeled. The cassava mill and waste receiving burrow pit are adjacent the Faculty of Engineering, Delta State University in Oleh, Delta State of Nigeria. The Faculty of Engineering is currently considering acquiring the burrow pit for fish farming. The study is therefore aimed at determining the suitability of the burrow pit or pond for the fish farming project. The mill processes cassava every three days, being the days that the community had chosen for all those wishing to harvest cassava roots to do so. This community legislation is as a result of incessant cases of cassava theft. So on the appointed days almost all in the community harvest cassava making the volume of cassava processed by this mill to be very high, since all in the area patronize it. The process steps employed by the mill include grating of the roots and squeezing by means of hydraulic presses. Some of the cassava owners also wash the peeled cassava roots in the burrow pit (pond).

2.2 Experimental Design and Method of Analysis

The main objective of the study is to investigate the effects of cassava processing wastewater on the quality of receiving stream or body of water, and as such the criteria proposed by Sarkar et al. [18] as applied by Okunade and Adekalu [4] in their work was adopted. Four different points along the pond were chosen for sample collection (i.e. the point of effluent discharge from the plant (DP), 10 meters west of the discharge point (10-W), 10 meters east of the discharge point (10-E) and 10 meters downstream of the discharge point (10-DS)). Samples for analysis were taken at the designated points in triplicate two days after processing operation for a period of four weeks. Collected samples were taken to the laboratory immediately after collection using plastic bottles properly rinsed with nitric acid. Prior to analysis, the samples were stored in a refrigerator maintained at 4°C. A total of 13 physicochemical parameters namely; pH, total cyanide (CN), total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), conductivity, turbidity, hardness, as well as the ions of lead (Pb^{2+}), iron (Fe^{2+}) and mercury (Hg^{2+}) were determined.

The TSS, TDS, DO, total hardness were determined by the UV absorption spectrophotometer at 220 and the metal ions at 420nm respectively;, while the Winkler's titrimetric method as applied by Omotioma et al. [3] was used to determine the COD and BOD. The pH, conductivity and turbidity were determined using the pH meter, conductivity meter and turbidity meter respectively.

2.3 Statistical Analysis

One-way analysis of variance (ANOVA) was used to compare three replications each of data obtained from the physicochemical analysis of the pond water collected at the designated sampling points while Ducan's multiple range tests was applied in separating the mean values at a level of significance established at 5% probability level. The analysis was implemented using Microsoft office excel 2007.

3. RESULTS AND DISCUSSION

3.1 Results

The results obtained from the four selected sampling points are presented in Tables 1-4.

Table 1. Physicochemical properties of water samples taken at the point of cassava processing plant wastewater discharge (DP) into the pond

Parameters	Week 1	Week 2	Week 3	Week 4	Average
pH	5.1±0.01	5.4±0.08	5.3±0.10	4.8±0.46	4.2±0.16
Total CN (mg/l)	38.2±3.4	40.2±1.5	38.1±0.82	39.3±1.02	39.0±1.69
Hardness (as $CaC0_3$) (mg/l)	92.3±0.05	88.8±0.08	90.1±1.04	93.4±0.89	91.2±0.52
TSS (mg/l)	4021±2.10	4001±1.02	4080±0.24	4018±0.67	4030±1.01
DO (mg/l)	4.21±0.05	3.78±0.02	4.03±0.01	4.18±0.00	4.05±0.02
TDS (mg/l)	980±2.10	988±0.42	950±0.56	980±0.50	975±0.90
COD (mg/l)	1235.1±0.15	1243.6±0.08	1225.8±1.2	1241.3±1.1	1236±0.63
BOD_5 (mg/l)	431.6±0.40	428.1±0.08	430.8±0.04	432.1±1.6	430.7±0.53
Conductivity (µS/cm)	1821±0.00	1826±0.01	1813±0.61	1827±0.08	1822±0.18
Turbidity (mg/l SiO_2)	15.1±0.01	15.8±0.00	15.1±0.00	15.8±0.00	15.5±0.01
Pb^{++} (mg/l)	0.05±0.01	0.01±0.00	0.08±0.01	0.04±0.01	0.05±0.01
Fe^{++} (mg/l)	0.04±0.01	0.03±0.00	0.04±0.00	0.05±0.01	0.04±0.00
Hg^{++} (mg/l)	0.03±0.01	0.03±0.00	0.04±0.01	0.03±0.00	0.03±0.00

Table 2. Physicochemical properties of water samples taken 10 metres east (10-E) from the point of cassava processing plant wastewater discharge into the pond

Parameters	Week 1	Week 2	Week 3	Week 4	Average
pH	6.3±0.05	6.8±0.01	6.3±0.00	6.2±0.01	6.4±0.02
Total CN (mg/l)	21.7±1.2	22.3±0.88	21.8±0.61	21.2±0.28	21.8±0.74
Hardness (as $CaC0_3$) (mg/l)	68.2±0.13	68.3±0.10	69.2±0.08	68.1±0.05	68.5±0.09
TSS (mg/l)	3612±0.48	3578±0.21	3612±0.06	3620±0.03	3606±0.26
DO (mg/l)	5.8±0.00	5.9±0.01	4.9±0.06	5.7±0.01	5.6±0.02
TDS (mg/l)	720±0.02	726±0.00	718±0.01	721±0.00	721±0.00
COD (mg/l)	98.4±0.04	98.2±0.01	99.1±0.18	98.2±0.05	98.5±0.07
BOD_5 (mg/l)	320.1±0.00	321.5±0.00	320.8±0.01	320.3±0.00	320.8±0.00
Conductivity (µS/cm)	1781±0.01	1782±0.00	1790±0.06	1780±0.01	1783±0.02
Turbidity (mg/l SiO_2)	10.5±0.01	10.5±0.00	10.4±0.00	10.4±0.00	10.4±0.00
Pb^{++} (mg/l)	1.02±0.04	1.05±0.02	1.03±0.01	1.02±0.00	1.03±0.02
Fe^{++} (mg/l)	0.32±0.00	0.32±0.00	0.32±0.01	0.33±0.00	0.32±0.00
Hg^{++} (mg/l)	2.32±0.07	2.30±0.02	2.30±0.00	2.29±0.06	2.30±0.04

Table 3. Physicochemical properties of water samples taken 10 metres west (10-W) from the point of cassava processing plant wastewater discharge into the pond

Parameters	Week 1	Week 2	Week 3	Week 4	Average
pH	6.2±0.01	6.6±0.04	6.2±0.00	6.4±0.001	6.4±0.02
Total CN (mg/l)	5.1±0.00	5.3±0.05	5.1±0.01	5.2±0.00	5.2±0.02
Hardness (as $CaC0_3$) (mg/l)	71.8±0.06	71.2±0.02	71.0±1.25	72.1±1.02	71.5±0.59
TSS (mg/l)	2230±6.32	2210±2.41	2230±0.88	2231±0.56	2225±2.54
DO (mg/l)	8.3±0.02	8.2±0.00	8.3±0.01	8.6±0.04	8.4±0.02
TDS (mg/l)	521±0.05	518±0.01	521±0.01	520±0.01	520±0.02
COD (mg/l)	68.5±0.06	68.2±0.02	69.0±0.04	67.9±0.28	68.4±0.10
BOD_5 (mg/l)	40.2±0.01	41.2±0.02	40.8±0.01	40.3±0.03	40.6±0.02
Conductivity (µS/cm)	1401±0.09	1406±0.02	1405±0.01	1404±0.06	1404±0.05
Turbidity (mg/l SiO_2)	8.1±0.01	8.2±0.00	8.1±0.00	8.3±0.04	8.2±0.01
Pb^{++} (mg/l)	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
Fe^{++} (mg/l)	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
Hg^{++} (mg/l)	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00

Table 4. Physicochemical properties of water samples taken 10 metres downstream from the point of cassava processing plant wastewater discharge into the pond

Parameters	Week 1	Week 2	Week 3	Week 4	Average
pH	6.8±0.02	6.6±0.04	7.0±00	6.8±0.06	6.8±0.03
Total CN (mg/l)	3.8±0.00	3.8±0.01	3.6±0.01	3.8±0.02	3.8±0.01
Hardness (as $CaC0_3$) (mg/l)	75.2±1.05	75.1±0.28	75.0±0.08	75.1±0.01	75.1±0.36
TSS (mg/l)	2031±0.00	2028±0.04	2031±0.00	2030±0.00	2030±0.01
DO (mg/l)	10.2±0.01	10.2±0.01	10.8±0.00	10.5±0.03	10.4±0.01
TDS (mg/l)	402±0.08	406±0.02	408±0.00	402±0.04	405±0.04
COD (mg/l)	52.8±0.02	52.2±0.00	52.8±0.04	52.7±0.01	52.6±0.02
BOD_5 (mg/l)	32.5±0.00	32.8±0.01	33.1±0.06	32.8±0.01	32.8±0.02
Conductivity (µS/cm)	1421±0.92	1418±0.88	1421±0.61	1421±0.08	1420±0.62
Turbidity (mg/l SiO_2)	6.9±0.01	6.6±0.00	6.8±0.00	6.8±0.01	6.8±0.01
Pb^{++} (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
Fe^{++} (mg/l)	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
Hg^{++} (mg/l)	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00

3.2 Discussion of Results

From the results presented in Tables 1 – 4, the cyanide content of the pond at the four sampling points show very high values with the highest values recorded at the wastewater discharge point (DP) and 10 metres east of the discharge point (10-E). The average cyanide content at the discharge point over the four weeks experimental period was 39.0±1.69 with a highly significant effect (p=0.042) while that for sample point 10-E was 21.8±0.74 mg/l (p=0.023) respectively. Though the values for the other two sample points at 5.2±0.02 (10-W) and 3.8±0.01 (10-DS) mg/l are relatively lower than for DP and 10-E they are still very high when compared to 0.01 mg/l allowable for domestic water by both WHO [19] and NIS [20]. The cyanide high value at the DP is as a result of discharge of fresh cassava wastewater directly from the hydraulic presses of the processing plant into the pond. The bitter cassava variety (*Manihot utilissima*) generally cultivated in the area due to its high yield has been found to contain high concentration of cyanide [5]. The high value recorded at 10-E on the other hand may not be unrelated to an illegal refuse dump site located adjacent to the pond very close to the sample point. Fresh cassava peels are usually deposited at this dump site which is eventually washed into the pond by surface water during rainfalls either as fresh peels or in a decayed state. It had been noted that *Manihot utilissima* peels are highly concentrated with cyanide [5,21,22], hence the high concentration of cyanide recorded at this point. High concentration of cyanide (>0.01 mg/l) in domestic and water body meant for fish farming is very dangerous to human health because cyanide when taken into the body either directly or indirectly affects the thyroid and the central nervous system which may lead to paralysis [19,20]. As can be seen in Fig. 1, the cyanide concentrations range between 3.8±0.01 and 39.0±1.69 mg/l for 10-DS and DP respectively. From this result it is evidently clear that this pond apart from not suitable for fish farming, it is toxic and can impact negatively on the health of the inhabitants of the catchment area.

The pH of the water ranged between 4.2±0.16 at the discharge point (DP) and 6.8±0.03 at 10-DP. This shows that the water is highly acidic which can be attributed to the high cyanide content of the water. As a result of the acidic nature of the water it could not be used for fish farming or for any other domestic purposes. As shown in Fig. 1, the turbidity of the pond is highest at the discharge point (DP) with a value of 15.5 mg/l SiO_2 which is equivalent to about 6.7 Nephelometric Turbidity Unit (NTU), while the lowest value of 6.8 mg/lSiO_2 which is equivalent to 2.93 NTU [23] was recorded at sample point 10-DS. The turbidity of water is a function of the total suspended solid (TSS) in the water. The higher the TSS the higher the turbidity value and the less clear the water will be. The trend can be seen in Fig. 2, with the highest value of TSS being recorded at sample point DP. Water with turbidity values of 10 and 25 NTU had been found to be ideal for use for drinking and fish farming respectively [23]

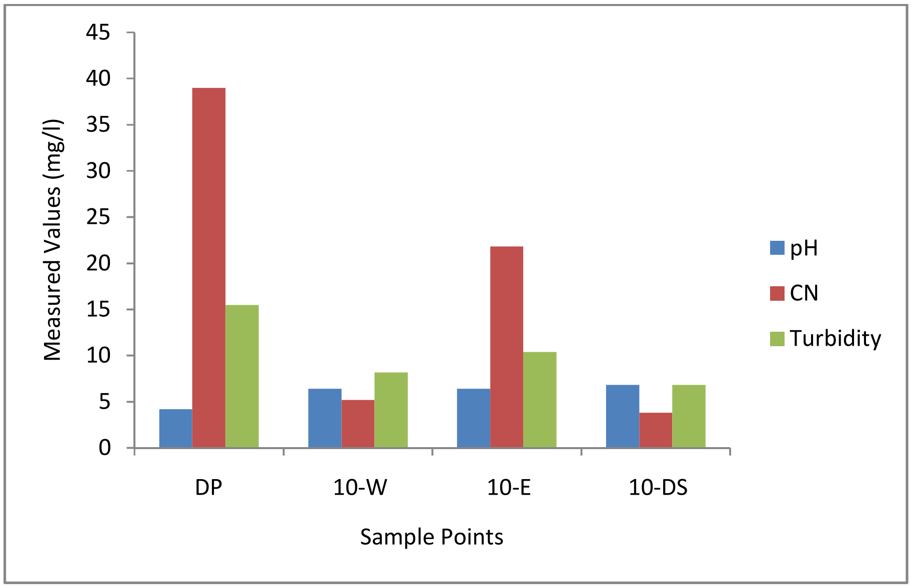

Fig. 1. Measured values of CN, pH and turbidity of the studied water body

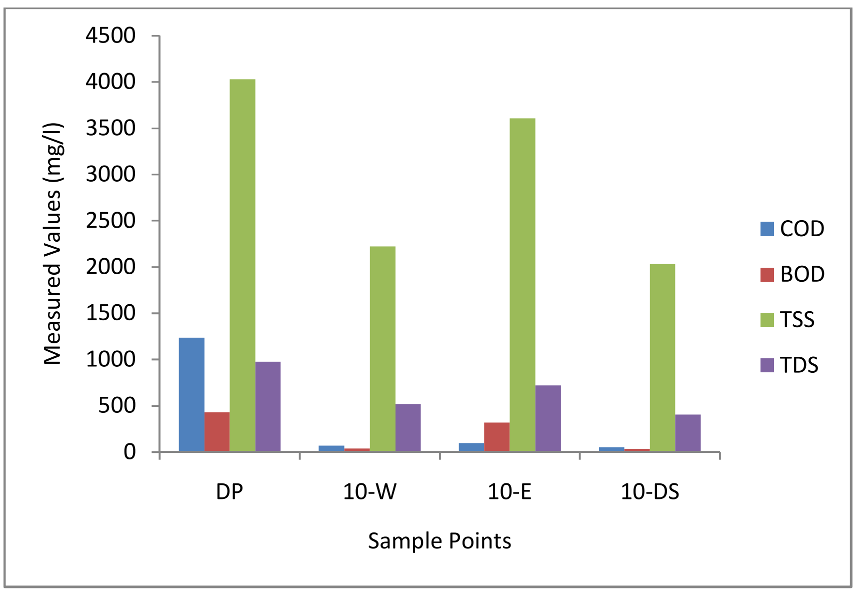

Fig. 2. Measured values of COD, BOD, TSS and TDS of the studied water body

The results show high values of COD, BOD, TSS and TDS at sample point DP followed by sample point 10-E as seen in Fig. 2. The COD at the discharge point (DP) was 1236±0.63 mg/l which is far higher than the permissible limit of 250 mg/l allowed for fish farming [24] while the BOD at the same point was 430.7±0.53 mg/l. Streams and ponds having BOD values above 30 mg/l is not suitable for fish farming since high BOD depletes the dissolved oxygen (DO) in the water responsible for supporting aquatic life. The TDS recorded at all the sample points except 10-DS are higher than the recommended values of 500 mg/l for streams and ponds meant to support aquatic life or for domestic application. The high TDS may be as a result of salt formation during cassava fermentation process as well as cassava peels decay and run-off from adjacent refuse dump especially at sample point 10-E [14]. The three metallic ions tested for show highly significant effect. The highest values of these ions were recorded at sample point 10-E which is located adjacent the refuse dump. At this point Hg^{2+} has a value of 2.30±0.04 while Pb^{2+} and Fe^{2+} were 1.03±0.02 and 0.32±0.00 respectively. These values are highly above the recommended values of 0.001, 0.01 and 0.3 mg/l for water bodies meant for the intended use. This result is not surprising since all sorts of metal scraps including spent motorcycle batteries as well as used engine oil are usually dumped at this illegal refuse dump site by motorcycle mechanic workshops located close to the study area. These wastes are then washed into the pond by rainwater. The high concentration of these metals in the water body not only render it unsuitable for fish farming but also pose grave danger to inhabitants living nearby and those who use water from the pond for washing and other domestic activities. High concentration of lead in water had been found to have lethal effects on both humans and animals. Lead is neurotoxin, it is therefore associated with lead poisoning [25,26,27] causing cancer and damage to the central and peripheral nervous system. Effects of lead also include interference with vitamin D metabolism causing impaired mental development in infants. High mercury concentration on the other hand affects the kidney and central nervous system. The lethal effects of these metals on the inhabitants of the study area may not clearly be evident now, since their effect is cumulative and therefore take time to manifest.

4. CONCLUSION

The results of the study show that the pond water is highly acidic due the high cyanide content of the discharged wastewater from the mill. The BOD, COD, TDS and TSS are also very high leading to depletion of dissolved oxygen (DO) needed for the survival of aquatic life. All the other parameters tested were clearly above the recommended limit for water bodies for fish farming. Indiscriminate dumping of refuse in and around the pond is responsible for the accumulation of lethal metal ions in the water with its attendant grave consequences to the inhabitants of the area. It is therefore obvious that the pond cannot be used for the proposed fish farming project by the Faculty of Engineering of the Delta State University in its present state. However, if the source of pollution is stopped with the illegal refuse dump evacuated and excavated, and the pond left for an extended period of time to remediate, it could be considered for the intended use.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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