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Impact of Gold Mining on the Biomass of *Synodontis membranaceus* Tengrela, Ivory Coast

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Abstract | **Original Research Article**

In the Bagoué region (Ivory Coast), gold panning is an environmental problem that negatively impacts the aquatic biodiversity of the Bagoué River. The fish Synodontis membranaceus is a highly prized species in this river. It is therefore necessary to understand the impact of gold panning on this species. Sampling campaigns were conducted every two months from August 2022 to February 2024 in Tengrela, an area with gold panning activity, and in Boundiali, an area without gold panning activity. The data collected were derived from experimental and commercial fishing. The *Synodontis membranaceus* fish caught were weighed to the nearest gram using a scale accurate to 0.1 g. Measurements of physicochemical parameters were taken in situ. The impact of gold panning on the biomass of Synodontis membranaceus was assessed by comparing the values of physicochemical parameters and biomass at the Tengrela and Boundiali sites. The results showed that in the area affected by gold mining, the amount of suspended matter increases while water clarity decreases. This leads to a decline in the biomass of Synodontis membranaceus in Tengrela compared to that in Boundiali.

Keywords: Ivory Coast, Bagoué, alluvial gold mining, biomass, Synodontis membranaceus.

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INTRODUCTION

Gold panning which refers to the extraction of gold, whether through artisanal or industrial methods is growing rapidly in many tropical regions, particularly in West Africa. Although it is a significant source of income for local communities, this practice has alarming environmental impacts, especially on aquatic ecosystems. In Côte d'Ivoire, in the Bagoué region, research by Kouamé *et al.,* (2020) showed that mercury levels in the Bagoué River, ranging from 0.64 µg/L to 0.72 µg/L, exceed the surface water standards (0.5 µg/L) recommended by the World Health Organization (WHO) in 2011. Consequently, this environmental imbalance leads to changes in the water's physicochemical parameters and a decline in aquatic biodiversity. However, the Bagoué River boasts a very rich fish biodiversity, which constitutes an undeniable asset for the riverside communities (N'da, 2015). Among the fish species found in the Bagoué River, the decision to study Synodontis membranaceus is a sound one. Indeed, Synodontis membranaceus is highly prized by consumers and also has a high market value (Kouyaté, 2022). Furthermore, it represents a fishery resource that is exploited year-round by local residents and in commercial catches. Finally, the Synodontis membranaceus catfish is abundantly present in the Bagoué River. However, the section of the Bagoué River that flows through the Tengrela department faces a serious problem with gold panning. Indeed, Kouyaté (2022) noted that artisanal gold mining is carried out intensively in the town of Tengrela, in Côte d'Ivoire. Thus, the purpose of this article is to demonstrate how gold panning can affect fish production specifically that of Synodontis membranaceus along the Bagoué River in northern Côte d'Ivoire.

MATERIALS AND METHODS

Study Site

The study is being conducted on the Bagoué River, located in the departments of Tengrela and Boundiali. The Bagoué River (Figure 1), located in northwestern Côte d'Ivoire, lies between longitudes 6°10' and 6°60' West and latitudes 9°10' and 10°20' North (Adja *et al.,* 2009). Its area is approximately 13,682 km² (N'da *et al.,* 2015), and its watershed covers

the departments of Boundiali and Tengrela. It initially flows west to east from Madinani to Boundiali and then south to north as it enters Malian territory, where it joins the Baoulé River before emptying into the Niger River. The Bagoué River flows for approximately 350 km, and its watershed covers an area of approximately 33,430 km². The Bagoué is influenced by the Sudano-Guinean climate, which is characterized by two seasons: a dry season and a rainy season. The dry season runs from mid-October to mid-July, and the rainy season extends from mid-July to mid-October. Sampling stations were selected based on the presence or absence of artisanal gold mining activities, their accessibility by road in all seasons, and the year-round availability of water. In total, two stations were selected: the Zanikaha station in Tengrela and the Samorosso station in Boundiali.

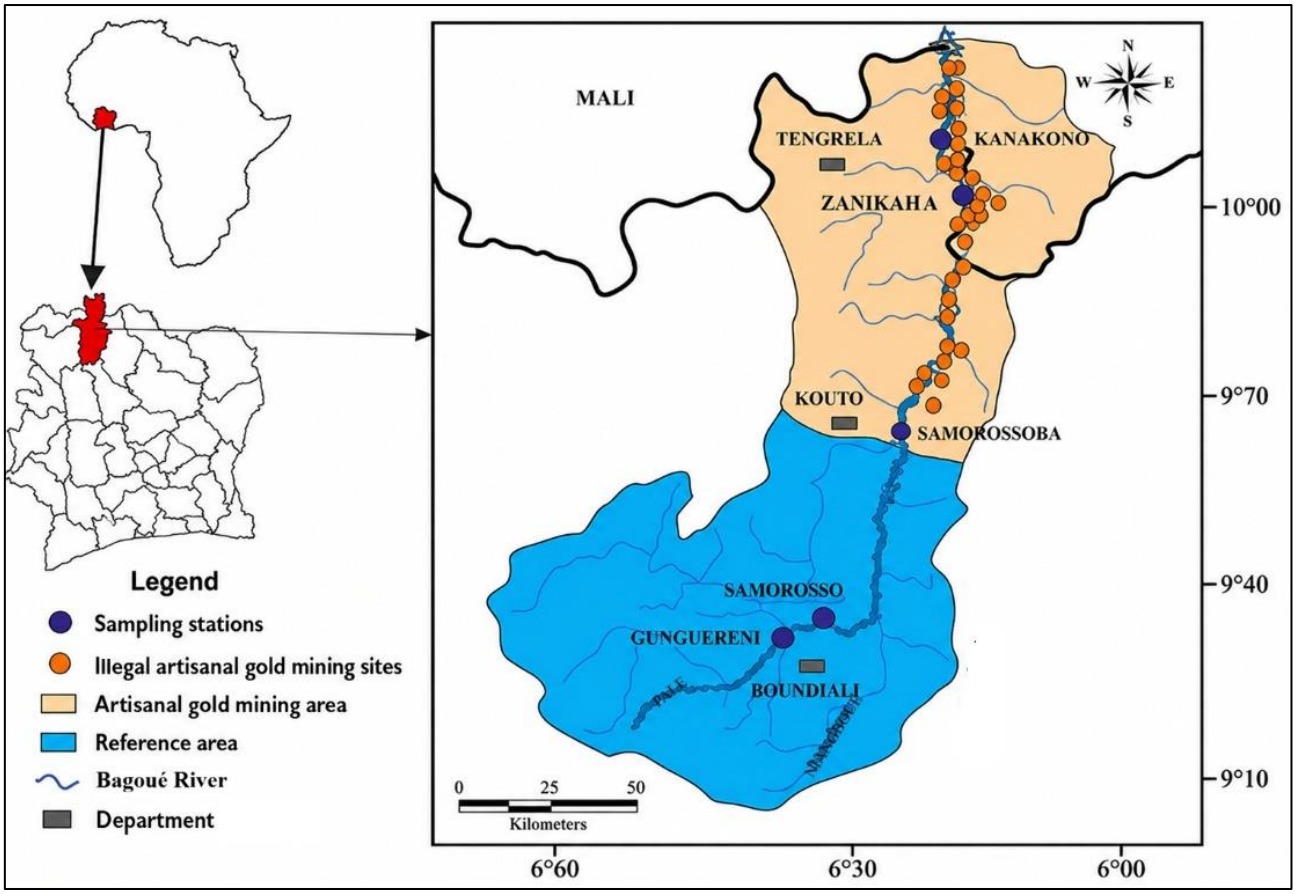


Figure 1: Locations of sampling stations and artisanal gold mining sites on the Ivorian section of the Bagoué River (Northern Côte d'Ivoire).

Study Strategy

The study of the impact of artisanal gold mining on the biomass of Synodontis membranaceus required the selection of a reference site and a test site. The site located in Boundiali, where no gold mining takes place, serves as the reference site. In contrast, the sampling site in Tengrela serves as the test site. The values for the physicochemical parameters and biomass at the test site are compared to those at the reference site.

Data Collection

Sampling, Identification, and Weighing of Synodontis membranaceus

Sampling campaigns were conducted every two months from August 2022 to February 2024. The biomass data for Synodontis membranaceus were obtained from experimental and commercial fishing. Experimental fishing involved setting nets at 5:00 p.m. and retrieving them the next day at 7:00 a.m. for night fishing, then resetting, checking, and retrieving them at 12:00 p.m. for daytime fishing. The captured specimens were identified using the identification keys proposed by Paugy *et al.,* (2003). The captured fish were weighed to the nearest gram using a scale accurate to 0.1 g.

Measurement of Environmental Variables

Measurements of physicochemical parameters were taken in situ every two months from August 2022 to February 2024. At each station, the various parameters were measured between 7:00 a.m. and 9:00 a.m. and between 5:00 p.m. and 6:00 p.m. using a HANNA 9828 multi-parameter meter with a digital display. The device was standardized and then calibrated before use. After turning on the device, the probe is submerged in the water (to a depth of the first 50 centimeters). Selecting functions such as temperature, pH, electrical conductivity, total dissolved solids, and dissolved oxygen allows for the automatic or digital display of the value of the selected parameter. To measure transparency, the Secchi disk, attached to a rope, is

lowered into the water until it disappears completely. It was then raised very slowly until it became visible. Measuring the distance, in centimeters, between the Secchi disk and the weighted rope allows us to determine the thickness of the euphotic zone or water clarity. The measurement of suspended solids (SS) involved collecting water samples using sterile gloves (Ghestem *et al.,* 2008) at a depth of approximately 10 cm (CCME, 2011; Morel *et al.,* 1998). The collected water was stored in sterilized 100-ml vials. Each vial containing water was labeled and then stored in a cooler in accor dance with the recommendations of the CEAEQ (2015) and AFNOR (2005). The various water samples were analyzed at the National Laboratory for Agricultural Development Support (LANADA) in Abidjan (Ivory Coast). Suspended solids (SS) were measured using the vacuum filtration method with a glass fiber filter having an estimated nominal porosity of 1.5 µm, in accordance with AFNOR (2005), and the results were documented. The amount of TSS (mg/L) in the samples was determined using the following formula, as specified by CEAEQ (2014).

$$[MES] = \frac{(Mf - Mi) \times 1000}{Ve}$$

[MES] is the concentration of suspended solids; M*f* is the mass of the filter after drying; M*i* is the mass of the filter before filtration; and V*e* is the volume of the water sample.

RESULTS

Values of the physico-chemical parameters of the water of the Bague river

The water temperatures recorded at Tengrela and Boundiali, respectively, are 27.46 °C (Table). The dissolved oxygen concentration in the water at Tengrela (3.90 mg/L) is lower than that at Boundiali (4.92 mg/L). The pH measured at the Tengrela station is 6.94, while that at the Boundiali station is 5.99 (Table). The water at the Tengrela station recorded a low conductivity value of 39.02 µS/cm compared to the value obtained at the Boundiali station, which is 54.17 µS/cm (Table). The total dissolved solids (TDS) concentration is higher at the Boundiali station (34.45) than at the Tengrela station (23.17). Measurements of suspended solids yielded a minimum value of 17.42 and a maximum value of 97.15 at the Tengrela station (Table). Water transparency values range from 22.15 cm to 55.75

Table 1: Values of physicochemical parameters measured at the Boundiali and Tengrela stations from August 2020 to February 2024

	Boundiali	Tengrela
Température (°C)	27,46±3,38	27,46±3,35
Dissolved oxygen (mg/l)	4,92±0,89	3,90±1,76
pH	6,94±0,58	5,99±1,23
Conductivity (µmS/Cm)	54,17±17,13	39,02±5,31
TDS	30,45±9,19	23,17±6,63
MES	17,42±6,31	97,15±109,90
Transparency (cm)	55,75±8,73	22,25±13,72

Biomass

The biomass calculated at the Tengrela station is 597 kg of total catch, while that at the Boundiali station is 2,549 kg of total catch. The biomass obtained at the Boundiali station is four times greater than that at the Tengrela station.

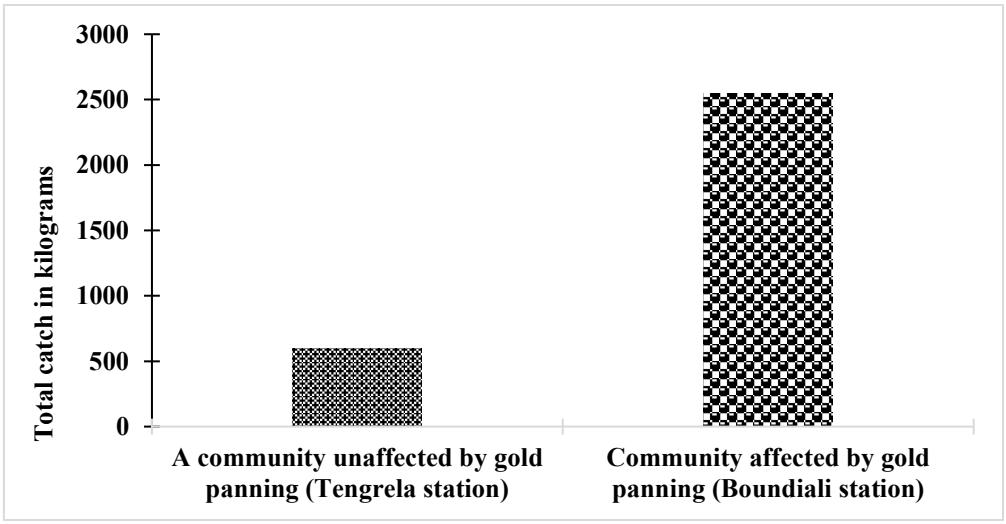


Figure 2: Total catch in kilograms at the Boundiali and Tingrela stations from August 2020 to February 2024.

DISCUSSION

The water temperatures of 27.46 °C recorded at Tengrela and Boundiali, respectively, fall within the temperature range (26.2 °C to 33 °C) characteristic of tropical waters (Camara *et al.,* 2012). These values of 27.46°C at both stations indicate that the water temperatures at these surveyed stations are warm. These data are consistent with Lemoalle's (1999) assertion that in intertropical Africa, average temperatures are high and most often exceed 20°C. High water temperatures may be caused by high ambient air temperatures in the Bagoué region. The dissolved oxygen concentration in the waters at Tengrela, in an area where gold panning occurs, is 3.90 mg/l, while that at Boundiali, in an area where gold panning does not occur, is 4.92 mg/l. These oxygen concentrations indicate that the waters at the study sites are well-oxygenated. In fact, surface waters are considered well-oxygenated when the dissolved oxygen concentration exceeds 3 mg/l (ABH, 2009). However, the Tengrela monitoring station, located in a gold panning area, has a low total dissolved oxygen concentration of 3.90 mg/L. The low oxygenation at this station can be attributed to the high concentration of suspended solids. In fact, this factor significantly limits light penetration into the lower layers of the river. This results in low penetration of the light essential for photosynthesis (Buhungu *et al.,* 2018) and an increase in algal and bacterial respiration rates, thereby causing a decrease in the oxygen concentration of the environment (Barillier *et al.,* 1993).

The pH measured at the Boundiali station is 6.94, while that at the Tengrela station is 5.99. This study indicates that the water at both stations is acidic. The acidity of the rivers could be of natural or anthropogenic origin (Rodier, 2009). Indeed, according to Kouyaté (2022), the discharge of domestic wastewater into the watercourse via runoff increases the level of organic matter in the water, thereby promoting an increase in the concentration of carbonic acid (H_2CO_3), which causes the pH to decrease.

The Tengrela station recorded low values for conductivity (39.02 µmS/cm) and TDS (23.17) compared to the values for conductivity (54.17 µmS/cm) and total dissolved solids (34.45) obtained at the Boundiali station. The stations studied generally exhibit low mineralization, as highly mineralized water has conductivity values ranging from 205 µS/cm to 1049 µS/cm (Goloma and Symoens, 1990).

However, conductivity and TDS values are low in Tengrela due to the large amount of suspended solids in the water. Indeed, these suspended solids are likely to form complexes with certain mineral ions, which reduces the amount of free ionic charges in the water (Werban *et al.,* 2009). The decrease in ionic charge would lower the water's conductivity at this station. However, dissolved salts are responsible for the mineralization of water and, consequently, for its conductivity (Edia, 2008).

Measurements of suspended solids yielded a minimum value of 17.42 at the Boundiali station and a maximum value of 97.15 at the Tengrela station. Furthermore, water transparency values were 22.15 cm and 55.75 cm at the Tengrela and Boundiali stations, respectively. The high levels of suspended solids and low water transparency observed at Tengrela are due to increased mining activity in this area. Indeed, dredging of the river's main channel by these platforms results in elevated levels of suspended solids and reduced water transparency. The presence of these particles absorbs light, thereby reducing its penetration to greater depths. These observations are corroborated by the work of Kouamé *et al.,* (2020) in the same watershed.

The biomass obtained at the Tengrela station (597 kg total catch) is very low compared to that at the Boundiali station (2,549 kg total catch). The low biomass of Synodontis membranaceus recorded at Tengrela is likely due to gold panning activities. Indeed, artisanal gold mining releases chemicals into the watercourse, which affects water quality and disrupts aquatic life (Kouamé *et al.,* 2020). Consequently, these disturbances are thought to cause fish to flee the habitat due to a lack of food and oxygen (Laperche *et al.,* 2007) and to lead to a reduction in fish species diversity (Jan and Paul, 2004). These observations are confirmed by the work of Kouamé *et al.,* (2020) on the Bagoué River. These authors demonstrated that gold panning increases turbidity due to particulate load while reducing the amount of oxygen produced in the environment, which causes fish to migrate to other suitable habitats.

CONCLUSION

The study conducted in Boundiali an area without artisanal gold mining and in Tengrela, an artisanal gold mining area on the Bagoué River, demonstrates the negative effects of artisanal gold mining on the biomass of Synodontis membranaceus. The Tengrela site recorded low values for dissolved oxygen (3.90 mg/L), pH (5.99), and conductivity (39.02 µS/cm), TDS (23.17), and transparency (22.25 cm) compared to the values for dissolved oxygen (), pH (), conductivity (54.17 µmS/cm), TDS (), and transparency (34.45) obtained at the Boundiali station. However, the suspended solids measurements at the Boundiali station (17.42) are very low compared to those at the Tingrela station (97.15). Furthermore, the water temperature is the same at both stations, at 27.46 °C. The biomass of Synodontis membranaceus recorded at the Tingrela station (597 kg total catch) is very low compared to that at the Boundiali station (2,549 kg total catch). Given the socioeconomic aspects of fishing and the importance of Synodontis membranaceus, it is necessary to raise awareness among gold miners about the environmental impacts of this activity.

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