Water and its biological resources sustainability in tropical developing countries: aquatic ecosystems health assessment

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Introduction

- Inland waters are natural resources with high economic, cultural, aesthetic, scientific and educational value, but they are under high human pressure and increasing climatic variability.
- Their conservation and management are critical to the interests of all nations and governments.
- Thus, thorough scientific knowledge of these valuable ecosystems is an essential prerequisite for developing reliable management tools applicable locally, essential for prioritizing conservation efforts and efficient management of streams in developing countries.
- This study was performed as a part of the APPEAR-sponsored SUSFISH Project with main aim to develop accessible tools, locally adapted for assessing the health of riverine ecosystems in West Africa, particularly in Burkina Faso.

Material & Methods

Study Area

- Burkina Faso is a tropical Sahelian country located in Central West Africa, with area of 27, 4200 km², and bordered by 06 countries.
- Burkina Faso is marked by wet and dry seasons.
- More than 20 Millions of people and high growth rate.
- Riverine ecosystems in Burkina Faso are impacted.
- The present study was conducted in Burkina Faso's three main river basins: Mouhoun, Nakanbé and Comoé (see Figure 1).

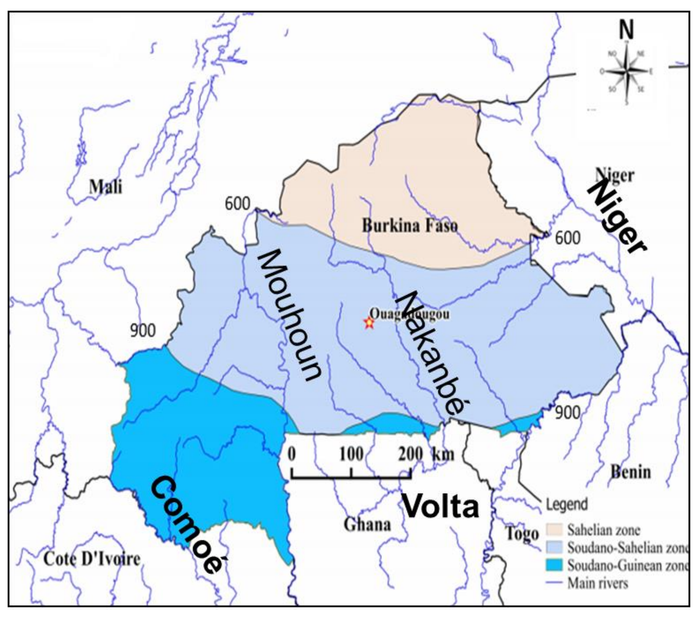

Figure 1 map of Burkina showing river networks where samples were taken.

- Five ecological classes were defined based on floodplain land use, experts' judgement and previous works for data collection (Figure 2).

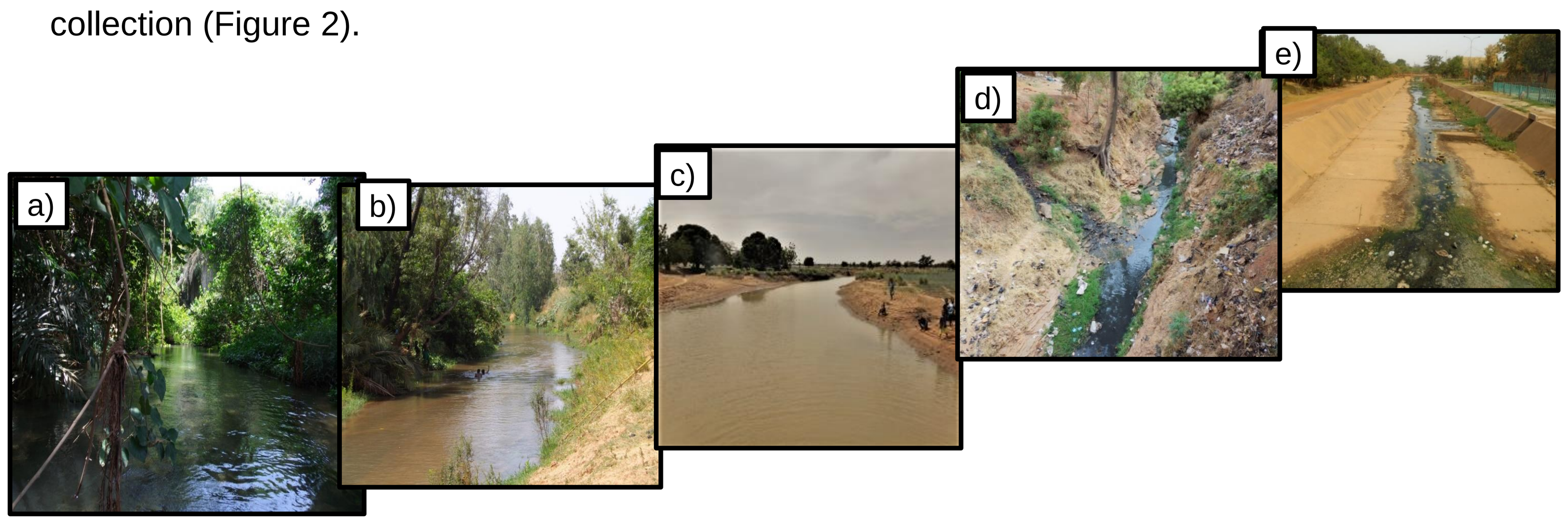

Figure 2 Sampling sites, with examples of the five ecological quality class sites (a) high ecological quality class site (ECI) (protected areas), (b) good (ECII), (c) fair (ECIII), (d) poor (ECIV), (e) bad (ECV)

Data collection and field treatment

Benthic invertebrates: MHS method using a hand net (25 x 25cm, Mesh size 500µm). One sample consists of 20 pooled sampling units (see Figure 3, data collection, coarse material sorting and sample labelled).

Figure 3 Field works steps. (a) Macroinvertebrate collection, (b) field treatment and (c) samples labelled

Laboratory processing

In the laboratory, prior to sorting out the organisms, samples were sieved and the animals were separated. The animals were identified with the dichotomic macroinvertebrates keys manuals (Figure 4, (a) samples sieving, (b) sorting and (c) identification).

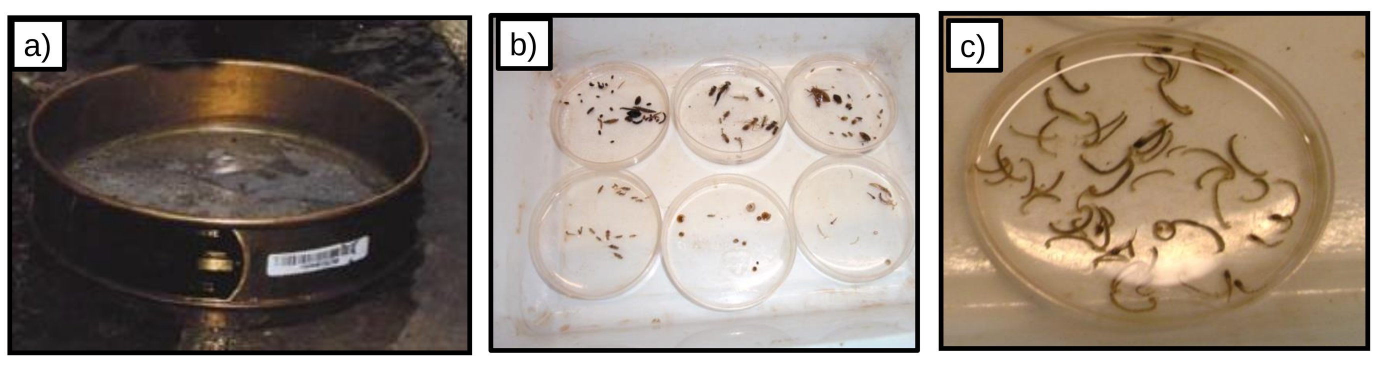

Figure 4, steps for proceeding macroinvertebrate identification. (a) samples sieving, (b) sorting and (c) identification

Taxa score calculation

$$Guide\ score = \frac{S_I}{S_{tot}} \times 10 + \frac{S_{II}}{S_{tot}} \times 7.75 + \frac{S_{III}}{S_{tot}} \times 5.5 + \frac{S_{IV}}{S_{tot}} \times 3.25 + \frac{S_V}{S_{tot}} \qquad (Eq. 1)$$

where S_I, S_{II} S_{III} S_{IV} S_V are total numbers of sites in each of the respective water quality classes where the taxon was recorded and S_{tot} the total number of) sites where the taxon was found and 2.25 is the score interval with 10 as maximum, a scale ranges from 1 point to ten points (five quality classes (Figure 5).

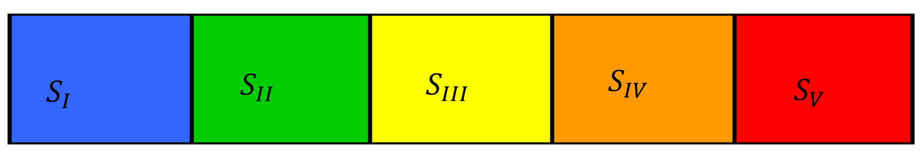

Figure 5 Sites categories

Burkina biotic Indices formulation and its performance with stressors

The Burkina biotic score system was calculated as the sum of sensitivity score of each taxon present in a sample as indicates equation 2:

$$\mathrm{BBIOSS} = \sum_{i=1}^{n} \mathrm{Score}_i \qquad (Eq. 2)$$

While the Average Score Per Taxon (ASPT) was calculated as Burkina biotic score divided by total number of taxa considered in the calculation following the equation 3.

$$\mathrm{BBIOSS-ASPT} = \frac{\sum_{i=1}^{n} \mathrm{Scorei}}{n} \qquad (Eq. 3)$$

Conclusion

In the present study, we developed a novel benthic invertebrate-based scoring system for rapid ecosystems health assessment in West Africa. From our findings, BBIOSS and BBIOSS/ASPT are suitable and effective tool to detect early environmental degradation, as they showed a solid response to the gradient of human impairment. BBIOSS and BBIOSS/ASPT is a rapid and practical assessment tool, with scope to be expanded to neighboring West African countries, and is highly effective for prioritizing water and biological resources conservation.

Results

Taxa and score

In total, more than 75 taxa of macroinvertebrates were recorded. Taxa scores sensitivity to human disturbances were ranged from 1 (very tolerant) to 10 (highly sensitive (Figure 6)

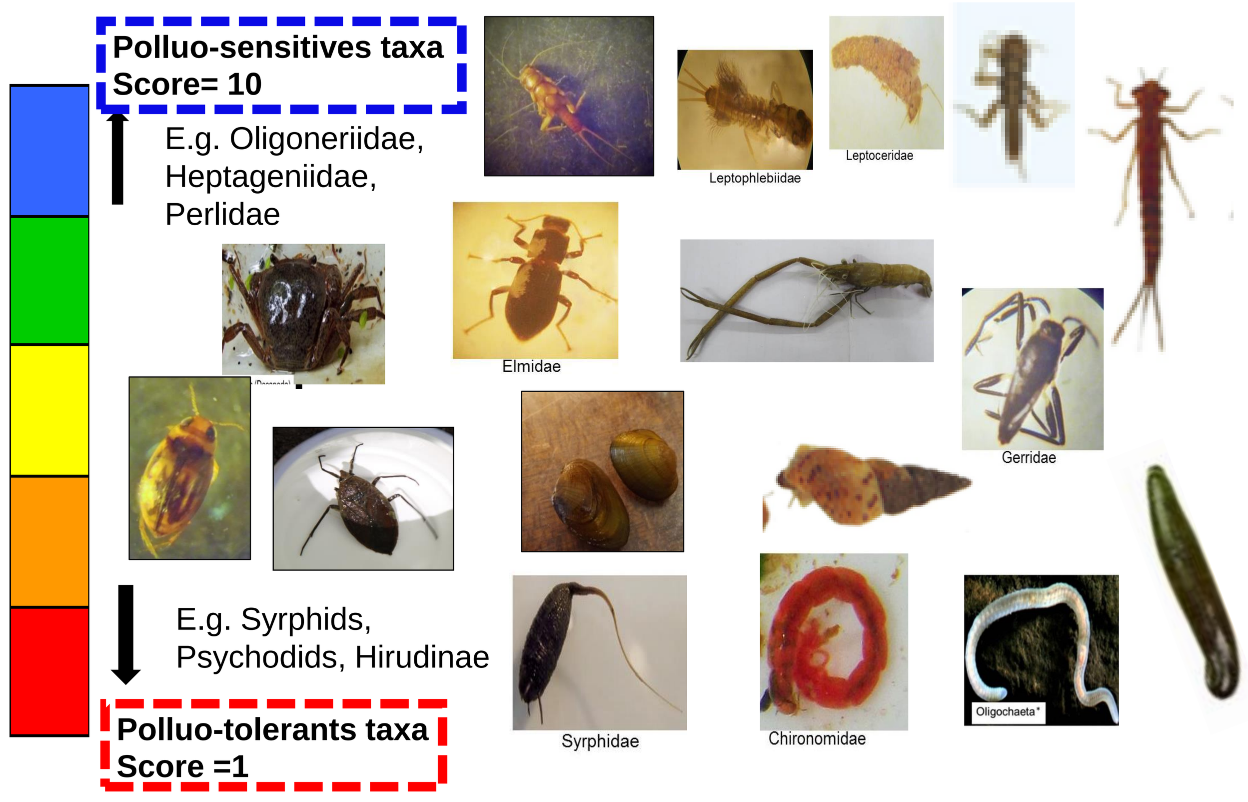

Figure 6 Macroinvertebrate taxa recorded and their sensitivity scores

Score index and ecological classes

- The figure 7 (a and b) shows the variations of BBIOSS and BBIOSS/ASPT across five quality classes from reference to bad sites.
- BBIOSS showed a slight variation in its sensitivity at good, fair and poor sites, "ECII", "ECIII", "ECIV", respectively, and decrease dramatically at bad sites "ECV", while BBIOSS/ASPT was efficient to clearly differentiated categories of sites "ECI" from "ECII", both (ECII, ECIV) and "ECV".
- From Figure 4 (Aa and Bb), we observed a weak seasonal variation of the two indices (BBIOSS and BBIOSS/ASPT.

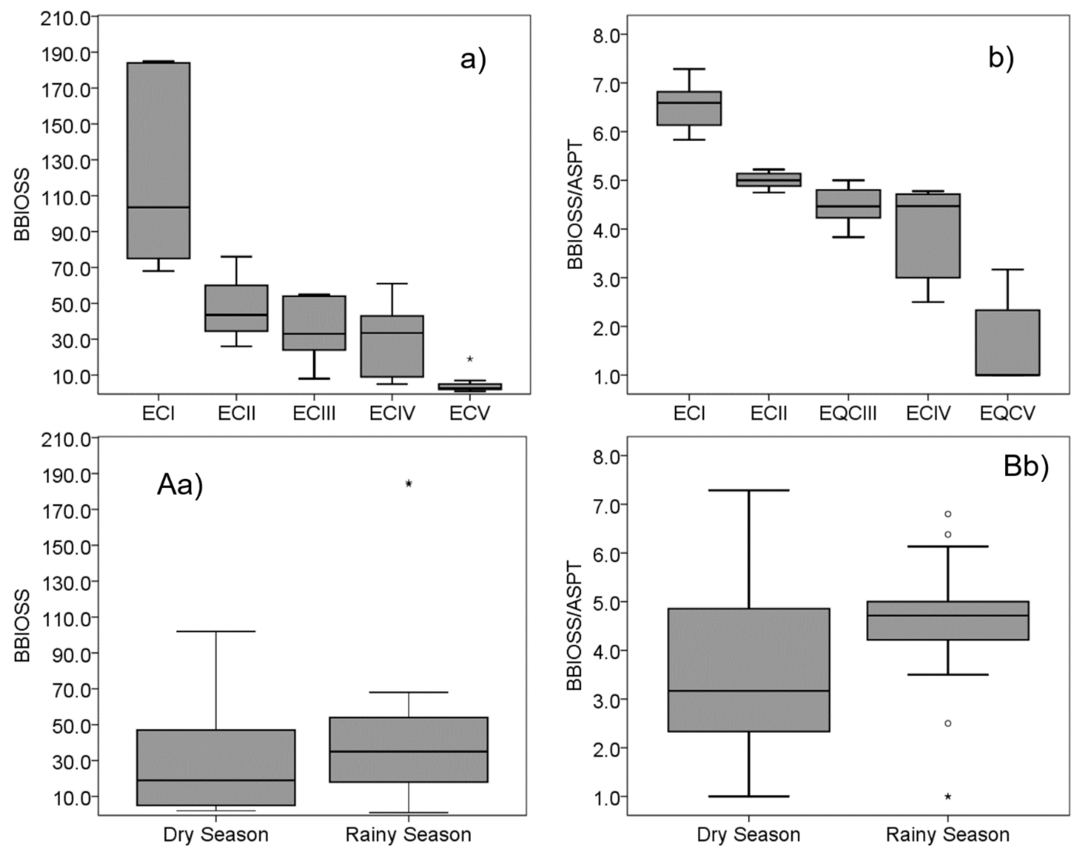

Figure 7 Variations of BBIOSS and BBIOS/ASPT across five categories of sites ECI, ECII, ECIII, ECIV and ECV (a, b) and their seasonal variability (Aa, Bb)

Narrative interpretation

For comprehensive interpretation of BBIOSS and BBIOSS/ASPT, values were divided into five ecological classes corresponding to different biological and water quality conditions (Fig 5): (I) High (BBIOSS >85; ASPT >6. 50), (II) Good (BBIOSS from 85 to 65; ASPT from 6.5 to 5.4), (III) fair (BBIOSS from 65 to 45; ASPT from 5.4 to 4.50), (IV) Poor (BBIOSS from 45 to 25; ASPT from 4. 50 to 3.4), and (V) Bad (BBIOSS <25; ASPT <3. 4).

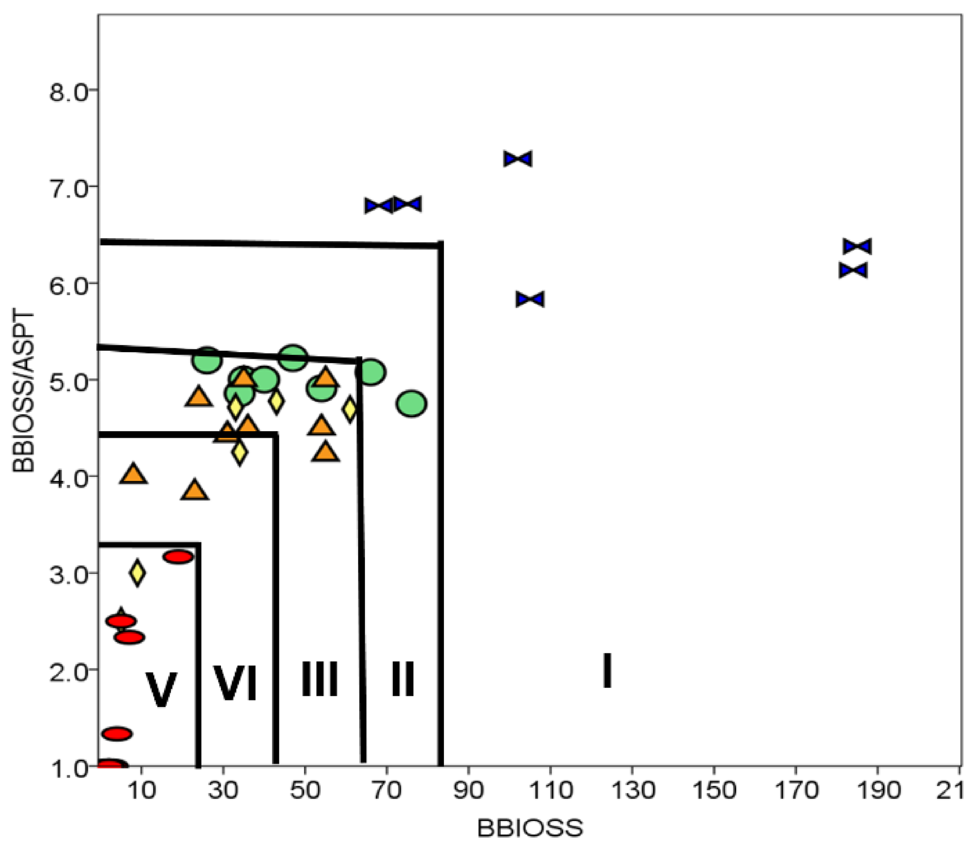

Figure 8 Proposed river ecological quality class boundaries for Sahelian rivers/streams. Blue = high quality class (I); green, good quality class (II); yellow, moderate quality class (III); orange, poor quality class (IV), red, bad quality class (V)

Stressors gradients

We found a strong, and negative correlation between BBIOSS/ASPT and water quality parameters (R^2>0.50), Organics nutriments (R^2>0.60), and habitat quality parameters (R^2>).

Table 1 Spearman rank correlation between BBIOSS (Burkina Biotic Scoring System), ASPT (Average Score Per Taxa) and water variables including stressors

Stressors	Biotic indices
Water quality parameters	R^2>0.50
Nutriments	R^2>0.60
Habitats Quality Parameters	R^2>0.70

Acknowledgements