

## **Water quality trends in the Mekong and Tonle Sap rivers at Phnom Penh city**

### **Evolution de la qualité des eaux du Mékong et du Tonle Sap à Phnom Penh**

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#### **RÉSUMÉ**

Le Mékong est une rivière de 4350km partie de Chine qui traverse la Birmanie, la Thaïlande, le Laos, le Cambodge et le Vietnam avant d'arriver en mer. Lors de la traversée de Phnom Penh, capitale du Cambodge, il subit deux influences majeures, celle des contaminations urbaines de cette ville de 2,2 millions d'habitants, et celle du Tonle Sap. Cette rivière relie le lac Tonlé Sap au Mékong, avec un fonctionnement singulier puisque le Tonle Sap coule alternativement dans les deux sens en lien avec les saisons sèche et humide.

Dans le cadre d'une étude d'extension et de création de plusieurs stations de traitement de potabilisation des eaux à Phnom Penh, le fonctionnement conjoint du Mékong et du Tonlé Sap a été étudié, en mettant en exergue la variabilité saisonnière de la qualité de leurs eaux, et les tendances d'évolution prévisibles à l'horizon des 10 prochaines années. Ce travail a permis de montrer l'impact des pollutions urbaines et l'effet significatif et atypique de la bascule des flux du Tonlé Sap entre la saison sèche et la mousson.

#### **ABSTRACT**

The 4350km-long Mekong river travels through China, Burma, Thailand, Laos, then Cambodia and Vietnam prior to arrival in the sea. While traveling through Phnom Penh, capital city of Cambodia, it is strongly influenced by urban contaminations of this 2,2 million inhabitants city, and by the Tonle Sap. This river links lake Tonle Sap to Mekong and has a singular functioning, with flux from Mekong to the lake in rainy season, and return flow from the lake to Mekong river at the dry season.

For the extent and building of new drinking water treatment plants in Phnom Penh city, the functioning of both Mekong and Tonle Sap rivers have been studied, more especially focusing on the seasonal variability of their water quality, and of the forecasting of this water quality for the 10 forthcoming years. This work enabled to demonstrate the increasing impact of urban pollution and the significant effect of the peculiar functioning of the Tonle Sap river.

#### **KEYWORDS**

Eutrophication, Mekong river, Phnom Penh, Tonle Sap, water quality

## 1 INTRODUCTION: OBJECTIVES OF THE STUDY

A new drinking water treatment plant had to be installed for supplying the increasing population of the Phnom Penh city. It could take water from Mekong or Tonle Sap rivers. The choice of the optimal location depended of the potential intake, and the treatment processes of the present and future raw water quality at this site.

The raw water at several existing water intakes have then been assessed to compare the Mekong and Tonle Sap rivers water qualities, and to evaluate the current trend of evolution of these water qualities. The paper focusses on the main obtained conclusions.

## 2 MEKONG RIVER WATER QUALITY AT PHNOM PENH CITY

Mekong river water quality was mainly assessed from the analysis performed by PPWSA (Phnom Penh Water Supply Authority) at the raw water intake upstream of the existing treatment plants in Phnom Penh city. It consists of Chroy Changvar from 2008 to 2014, and Chamcar Mon from 2008 to 2014. Some of the main conclusions are as follows:

- Turbidity and suspended solids fluctuate according to a seasonal cycle, with minimum value in dry season and peak values during the rainy season.
- Peak of Iron (up to 3,4mg Fe/l) are obtained at the beginning of the flooding period, and there is a trend of increasing concentration that could be due to modification of soil occupancy upstream of Phnom Penh on the Mekong river watershed. Chromium also tend to increase with time, and could exceed the drinking water standard (50 $\mu$ g Cr<sup>6+</sup>/l) in the forthcoming years.
- There is a trend of increasing eutrophication. Indeed, phosphorus has strongly increased in 7 years (Figure 1), dissolved oxygen in surface waters is up to 130% oxygen saturation, and eutrophication also leads to a decreasing trend of nitrates concentrations (from 1,25 to 0,9 mg NO<sub>3</sub>/l).
- Organic matter tends to increase (BOD<sub>5</sub> mean value varying from 1 to 1,8mg O<sub>2</sub>/l in 7 years, and peak value up to 9,8mgO<sub>2</sub>/l), whereas *Escherichia coli* has strongly increased with an annual mean trend from 200 to 1000 cfu/100ml, and peak value up to 26000 cfu/100ml). The maximum levels are obtained concomitantly with the rainy season.

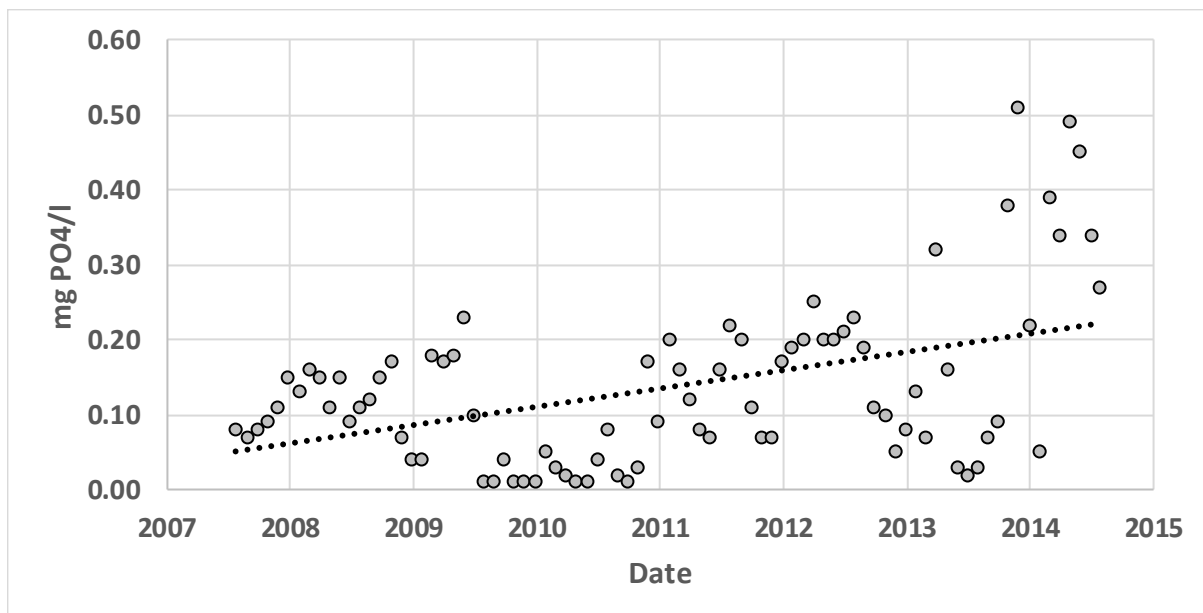


Figure 1: Orthophosphates (in mg PO<sub>4</sub>/l) at Chroy Changvar intake (Mekong river), plus the annual trend (dot line)

## 3 TONLE SAP RIVER WATER QUALITY AT PHNOM PENH CITY

Water quality of the Tonle Sap river was mainly assessed analysis performed by PPWSA (Phnom

Penh Water Supply Authority) from the 2006 to 2014 at the raw water intake upstream of the existing Phum Prek treatment plants in Phnom Penh city. The main conclusions are as follows:

- Mean turbidity tends to decrease from 120 NTU to 100 NTU, but Suspended Solids (SS) tends to be stable (with maximum value of 500 NTU and 800mg/l during rainy season). Iron concentration tends to increase, with peaks values (up to 6,4mg Fe/l) during rainy season
- Dissolved oxygen tends to decrease from 80% to 60% (mean annual saturation index) potentially due to the increase of organic matter and ammonium concentration. The minimum value is close to anoxia. The level of BOD<sub>5</sub> tends to increase (Figure 2). The microbial level is high and rather stable, with 8000 cfu/100ml for E Coli, meaning 8 times the mean concentration in Mekong River at Chroy Sangvar.
- Nutrients concentrations tends to increase for phosphorus (130 to 210µg PO<sub>4</sub>/l with peak concentration of up to 700µg PO<sub>4</sub>/l) and ammonia (from 0,2 to 0,6 mg N-NH<sub>4</sub>/l with peak concentration of up to 1,6 mg N-NH<sub>4</sub>/l), and to decrease for nitrates (from 1,7 to 1 mg N-NO<sub>3</sub>/l with minimum concentration of 0,4mg N-NO<sub>3</sub>/l,
- The Tonle Sap water quality is worst in spring (end of the dry season/beginning of the rainy season), probably due to concentration of urban contaminations at low flow, and soil erosion at the beginning of the rainy season.

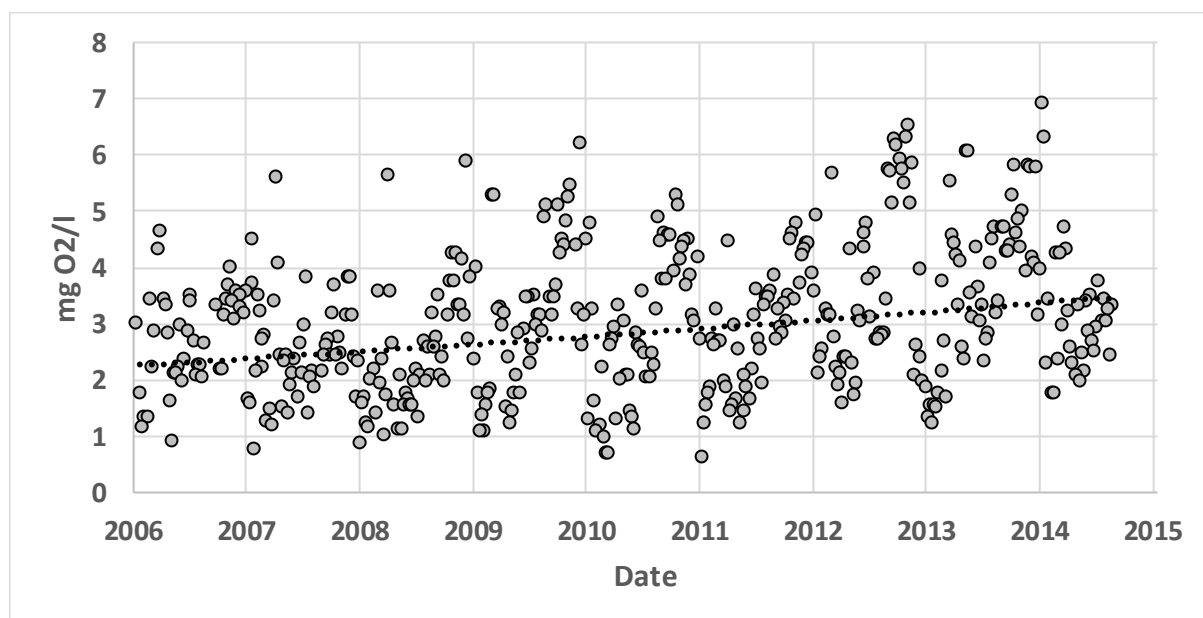


Figure 2: BOD<sub>5</sub> concentration (in mg O<sub>2</sub>/l) at Phum Prek intake (Tonle Sap river), plus the annual trend (dot line)

#### 4 FORCASTING OF THESE TWO RIVERS WATER QUALITY AT PHNOM PENH CITY

We can expect an improvement of the sanitation and wastage management in Phnom Penh. But the population will concomitantly increase and it is not sure that the fluxes of pollutants entering the Tonle Sap and Mekong rivers will decrease. The reverse would be more probable. At this stage, there are several concerns:

The city will develop in its northern part, that will increase the input of organic matter, nutrients, heavy metals, hydrocarbon, pathogens... in the Mekong river and in the Tonle Sap. Due to lower flow, Tonle Sap is more vulnerable than Mekong to this contamination.

The eutrophication tends to increase because of the higher level of organic matter and nutrients in the water. It may lead to instable system in the forthcoming 10 to 15 years considering the current trend) with occasional anoxia occurrence in the Tonle Sap River and concomitant increase of ammonium and organic levels. Such occasional anoxic conditions in the bottom sediments could lead to concomitant potential peaks of heavy metals in the water. The trend of nitrates decrease is linked with eutrophication. If nitrates were to disappear during late winter early spring period, it could lead to the

domination of cyanobacteria from the *Nostocales* order. These phytoplankton cells can be potentially toxic. This risk is presently limited, but any evolution of the eutrophication level must be surveyed in order to anticipate potential problem.

These problems could locally spread from the Tonle Sap to the Mekong river at the end of dry season when Tonle Sap flow from the lake to the Mekong.