Effect of increased temperatures on the Fraser River Main Arm's Water Quality

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Computation in the Physical Sciences
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November 18, 2015

Abstract

The basic physical conditions of rivers such as dissolved oxygen levels, temperature, ph and dissolved metals are essential for understanding the water quality of water body.Due to climate change B.C. is threatened by increasing temperatures. Increased temperatures are likely to affect other conditions needed for a healthy water quality. This study aims to understand the relationship between temperature and dissolved oxygen in the Fraser River Main Arm. An understanding of dissolved oxygen acts as an indicator for good water quality. This also creates a prediction for the life span and fate of salmon spawning in the Fraser River. Such study is completed using Python programming language for data analysis. Results show that increasing temperatures of the Fraser River will reduce dissolved oxygen levels.

Introduction

An increase in global temperatures of 2 degrees celsius can impair water quality of global water sources (IPPC). This impairment is due to the fact that with increasing temperatures there is more likelihood of eutrophication developing which eventually reduces the productivity of the water body in addition to changes in the ph levels and biochemical reactions (IPCC). Healthy water quality is measured based on ph levels, dissolved nutrients, dissolved oxygen and the phosphorus to nitrogen ratio. An understanding of dissolved oxygen (DO) is significant as this parameter has one larger influences on water quality and the other parameters (Delpla, A.-V. Jung, E. Baures, M. Clement, O. Thomas, 2009). Dissolved oxygen is formed when oxygen enters the water column via the atmosphere and plants with the banks of rivers and lakes (EPA). The flow of the river, particularly the constant mixing of the river dissolves the oxygen in the water column. Dissolved oxygen is altered when exposed to extreme temperatures and is affected by the altitude of the river's site. If river becomes hypoxic (reduction in oxygen levels) there is a reduction in the productivity of the river as organism lack oxygen to complete their metabolic processes (EPA).

In B.C adequate amount of dissolved oxygen is crucial, mainly for the spawning of Sockeye and Chinook salmon that uses the Fraser River as their river to spawn. Also, this salmon farming is one of the largest industries to B.C economy. On average in B.C., 25,000 individuals are employed and $230 million is generated from wholesale of salmon (SFU). There is also the First Nation community of B.C that relies on salmon as their main protein for their diet. If dissolved oxygen levels fall below 5 mg/L, salmon is reduced as such DO levels is not habitable for spawning. A domino effect results seeing that this hampers the job market of commercial fishing and direct food source of the First Nation communities. It is likely that this will create lead to more competitive industries and the need for creation of more job which are already lacking thus affecting the GDP of B.C (Cross, P). This loss in productivity results in death of the fishes and other organisms leading to a foul smell of the river. Additionally, rivers clarity are impaired. Therefore, the river is less habitable. Many communities are established along river banks due to the aesthetics of the area. Increased temperature which indirectly affects the quality of the lake reduces the economic sustainability of these communities as fishing activities are ceased. Therefore it is essential to consider dissolved oxygen as a parameter of water quality.

British Columbia (B.C.) experienced one of its hottest the 2015 summer (**BRIAN MORTON, 2015**). Temperatures during this period was a high of 35 degrees celsius. As mentioned, this increase in temperature impairs the water quality of rivers. B.C is strategically situated where it does not has a constant supply of water refilling its' lakes and rivers thus having a high flushing rate. A high flushing rate is optimal for healthy water quality as the constant 'replenishing' of the water source dilutes potential contaminants. Chemical contaminants are the most common source of degradation of water quality, though recent studies have shown that extremities in weather conditions such as unexpectedly high local temperatures can interrupt the main processes that are at a required threshold for a healthy water quality(IPPC). B.C's recent trend of increasing temperatures is likely to result in changes in physical processes that affect the dissolved oxygen levels and dissolved metals.

The Fraser River is the largest river in B.C. with a drainage basin of 25% of the province and major economic source for the province (Ministry of Environment, Lands and Parks of B.C, 1998). The annual average flow rate of the river is 3475 m^3/s, maximum 139,000

m^3/s and minimum ranges from 575 to 1040 m^3/s with a drainage basin of 217,000 km^2 (Ministry of Environment, Lands and Parks of B.C, 1998). Rocky Mountains are the source of the Fraser River and discharge station is strait of Georgia within the Vancouver region (Ministry of Environment, Lands and Parks of B.C, 1998). The gross income from this site is due to the fact that the river is home to one of the largest salmon run where salmons are one of the main fish catch for fishing industry. Impairment of this river's water quality will negatively affect the province since the province benefits from its healthy system. Rising temperature is likely to affect its dissolved oxygen content and salinity levels. The Colorado River experienced increased temperatures during drought conditions which resulted in reduction in dissolved oxygen and salinity changes. This is not a good change seeing that it affects the aquatic life in this region. Salmon are highly sensitive to a change in temperature. So though a reduction in dissolved oxygen is a major setback the independent variable in itself has consequences on the ecosystem. Salmons can only thrive in environments where the maximum temperature is 20 degrees celsius. Climate models that extrapolate temperatures have shown that in the future river temperatures can get raise to 24 degrees celsius (Morrison J, Quick, M. et al. 2002). This is not habitable for salmon as a temperature above 20 degrees is not conducive environment for spawning (Morrison J, Quick, M. et al. 2002).

The aim of this paper is to analyze the possibility of changes in dissolved oxygen due to increases in temperature as climate change has shown significant evidence that temperatures can soar above average. We hypothesize that this case is likely, seeing that such instances occurred in Colorado River ,which is shares similarity to Fraser River, indicates that this event is likely to occur in the Fraser River.

Methods

As a means of understanding the relationship between temperature and dissolved oxygen data on the Fraser River's Main Arm was sourced from Environment Canada online data portal. The main arm of the river was the main study sites was it has a buoy is on site which collects real time data thus provided 'precise' data was assessed via coding with python. Complete data for the hypothesis was available for years 2009- 2015.

An ipython notebook aided the initial testing of the code before transferring it to the script. Within ipython notebook the libraries ,such as: pandas '0.17.0', matplotlib, statsmodel and patsy, aided in completion of the analyses.Using these libraries, the following steps were executed to complete the analysis: Loaded the dataset into ipython notebook using the pandas library; organized the data to include columns that concerned the variables of concern; removed the rows that did not contain any values; changed column names to a simplified form; ran a linear model on the data which as aided by the library, statsmodel and created a plot of the linear regression.This notebook was then download as a .py to allow the development of a script for the codes.

Results

The raw data was analyzed to arrive at the following results.

	Sample_time	Temperature_Lab80	Oxygen_Dissolved_Lab-54
49	2012-04-27 21:40:00	7.5	12.00
53	2012-07-13 20:40:00	16.5	10.50
64	2013-05-03 19:30:00	7.5	12.70
69	2013-07-11 18:35:00	17.5	10.15
70	2013-07-25 18:00:00	19.5	9.38
73	2013-09-04 19:10:00	20.0	9.05
74	2013-09-17 19:25:00	20.6	8.96
75	2013-10-02 20:45:00	12.2	9.70

Figure 1. Table showing the main variables (Temperature and Dissolved Oxygen) collected at the Fraser River Main Arm on specific dates and time which is seen in the Sample_time column.

Stat	Values
P-value (Temperature values)	0.002
R^2 value	0.812
Standard Error for Intercept	0.719
Standard Error	0.045

Figure 2. Table showing the a summary of the main statistical information from the linear model

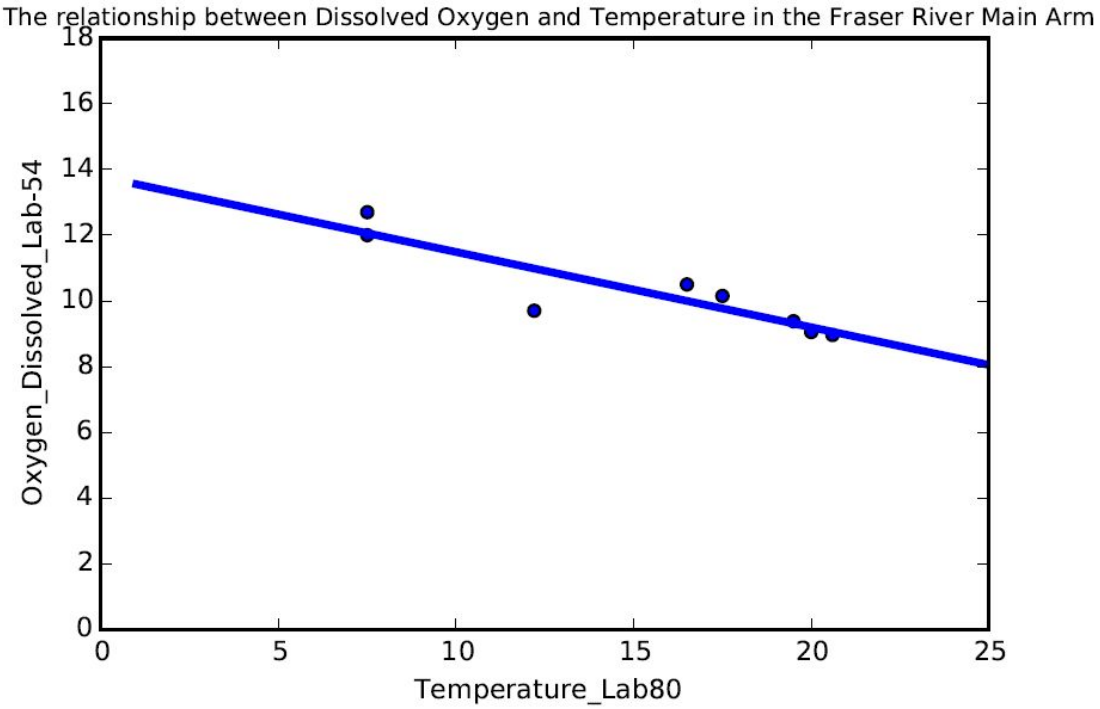

Figure 3. Linear regression showing the relationship between temperature and dissolved oxygen in the Fraser River Main Arm where the R^2 value is 0.812.

Discussion

Dissolved Oxygen is crucial for a healthy water quality. In recent years, due to climate change dissolved oxygen levels have not been able to maintain the appropriate threshold value due to warming of local temperatures. A temperature increase of the minimum 2 degrees celsius can have serious impact on water quality.

In this study it was found that there is high correlation between the increased temperature and dissolved oxygen. This was seen through an investigation of the R^2 values, which was 0.812, concluded that the values in x can be explained by the values in y, where x is the dissolved oxygen and y is temperature. The hypothesis of this problem is highlighted to be accurate seeing that there is positive relationship between temperature and dissolved oxygen.The p-value observed for the test was 0.002. This p values is less than the significance level 0.05, therefore the result is not statistically significant and the we fail to reject the null hypothesis.

Though the dataset gave meaning statistical result these results cannot be used to extrapolate future relationship between dissolved oxygen and temperature due to the small size siz used. However, this is dataset is helpful in that it acts as snapshot of the problem thus can be used by policy makers and engineers in the initial processes for projects governing similar framework.

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