Carbon emissions measurement using portable emission device in coastal fishing boats

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ABSTRACT – This paper measure the carbon emission from small scale fishing boats. Carbon emissions were measured from two types Class A Malaysian fishing boats marine engines covering various size of inboard engines and outboard engines. The gas emission analyser MSA Altair 5X used is portable and easy to handle. Selected fishing boats were sampled from a total of 664 fishing boats operates in Manjung, Perak. The results of carbon emission measurement were presented in parts per million (ppm). The outboard powered fishing boats recorded the highest carbon value in ppm about 2000 ppm meanwhile inboard powered fishing boats constitutes slightly less carbon emission with 379 ppm. The results signify that outboard engine fueled by petrol producing more carbon value if compared with inboard diesel engine. These results can be an initial data for carbon emission inventory for local fishing boats.

1. INTRODUCTION

Emission issues are always become an important topic over the decades as it is contributing to air quality level. Emission come from various source including marine transport. In general, the marine transport responsible about 2.8% of global carbon emission and expected to be increase by 50% to 250% in period to 2050 [1]. The increasing demand for marine transport service has cause the rise of emission as well. In case of fishing industry, the carbon emissions from fishing vessels still make a significant contribution if not much. Fishing vessels are heavily dependent to fossil fuels such as diesel and petrol to generate power. Combustion of fossil fuel however would generate greenhouse gas (GHG) emission and the concomitant impact on the environment.

The main exhaust gas emissions from ships include CO2, NOx, SOx, CO, hydrocarbons, and particulate matter. As there are raised concern on reduction of emissions, greenhouse gases (GHG) measure from fuel uses has become important aspect to be addressed. Among the gas emission, carbon emission is considered as the most important anthropocentric GHG as illustrated in Figure 1.1. Carbon emissions are form of CO and CO2. Numerous papers have been published on determining CO2 gas [2] and compared to CO gas. Carbon monoxide (CO) is a tasteless, odorless and colorless gas. It is a by-product of partial combustion of organic compounds. This paper focus to use portable emission to measure CO gas. However, others emission gaseous can be measured using the similar method as well depending on the sensor equipped.

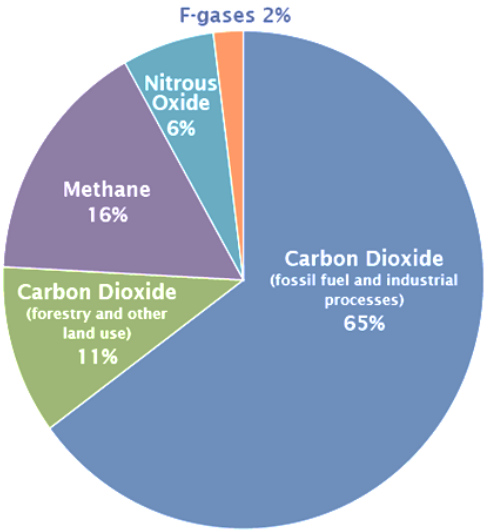


Figure 1.1 Global emissions shares

Emissions can be estimated using various method and formula. There were many study in emission estimation with various methodologies such highlighted [2-8]. In general, emission can be determined through direct measurement or empirical approach. The most widely used method of estimating emissions from ships is through an empirical approach. A complete methodology was developed in 2006 [9]. Later in 2009, EMEP/EEA proposed the estimation model which categories into 3 methods namely Tier 1, Tier 2 and Tier 3 [10].

Tier 1 method is the simplest method used to estimate emission by using emission factor. Tier 2 can be regarded as updated version of Tier 1 which default emission factors were replaced by country-specific emission factors. Emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all

available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category [11]. The Lloyds Register (2015) [12] provide the emission factor (kg/kWh) of different substances for diesel engines as listed in Table 1.1.

Table 1.1 Emission factor from Lloyds Register

Substance	Emission factor scientific notation (kg/kWh)
CO	0.0016
CO2	0.66
HC	0.0005
SO2	0.0064
NOx slow	0.017
NOx medium	0.012
PM fuel oil	0.0015
PM gas oil	0.0002

The field measurement of emission will provide more accurate data rather than simply using existing emission factor however costly and time consuming. Hence, the empirical calculation using emission factor is considered more preferably due to simple calculation and cost effective. However, there is an accuracy issue on emissions estimation from local fishing boats when some inputs emission factors for local fishing boats are not exist whereby the recent GHG data are hard to be applied due to localized factor. Furthermore, the lack of local inventory data of emission factors.

Several studies have been conducted to determine emission from Malaysian fishing vessel as carried out by Saad [13]. Saad has determined carbon emission from fishing vessel using tier 1 method waterborne navigation method. The author measure at four fisheries districts in Selangor during fishing vessels anchored for operation using emission factor derived from EPA. It is important to mention that emission estimation using non localised emission factor would not reflect to the actual results.

The regulations of controlling emission from marine transport was established by IMO in 2005 [14]. The International Maritime Organization (IMO) adopted an international convention protocol to reduce air pollution from ships, in order to achieve sustainable maritime development. This protocol approved by 15 member countries and enforced in May 2005.Thus, a field emission measurements of Malaysian fishing vessels is important steps towards developing a country emission inventory for fishing industry.

2. RESEARCH METHODOLOGY

The gas emission analyser MSA Altair 5X was used for measuring the carbon emission. The device specifications of the exhaust gases were shown in Figure 2.1 and Table 2.1. Altair 5x is a multi-gas detector that able to detect combustible gases and certain combustible vapours, oxygen-deficient or oxygen-rich atmospheres and specific toxic gases for which a sensor is installed. This device measure gas concentration in particle per minute (ppm) In house calibration was made to ensure the accuracy of device at accepting level according to manufacturer manual.

Figure 2.1 Altair 5x

Table 2.1 Altair 5x specifications

Dimensions (L x W x D)	6.69" H x 3.49" W x 1.79" D without belt clip or IR sensor
Weight	1 lb (without IR sensor)
Drop test	10 feet
Audible alarm	>95 dB typical
Visual alarm	2 ultra-bright LEDs, on top
Battery	Rechargeable Li-ION or AA alkaline
Run time	20 hrs @ room temperature
Charging time	≤ 6 hours
Operating temperature	–20˚C to + 50˚C
Short-period operation	–40˚C to + 50˚C
Data log	Adjustable, 200 hrs minimum

2.1 Field Test Location and Boat Particulars

For research area, fishing community in Manjung, Perak has been selected as case study. These locations were selected due to large number of fishing boats operation which constitutes about 664 fishing boats [15]. Exhaust carbon emission tests were made both from inboard fishing boat and outboard powered fishing boat as shown in Figure 2.2(a) and Figure 2.2(b) respectively. The activities of fishing operations are divided into four zones fishing operations A, B, C, and C2.

For this study class A fishing boat was selected. Class A is classified fishing zone less than 5 or 8 nautical miles from shore, reserved solely for small-scale fishers using traditional fishing gear and owner-operated vessels. Class A fishing boats engines come in two broad categories outboard or inboard. These different engine types have markedly different emissions characteristics. Engine horsepower selected according the Number of Licensed Fishing Vessels by State and Horsepower on 2015 issued by the department of fisheries Malaysia as shown in Table 3 [15]. The most widely used craft was the wooden vessel. All vessels were motorized and the engine horsepower (HP) ranged from 10 to 149hp. The

average of inboard wooden fishing boat not exceed 24m in length according to small fishing vessel regulation.

(a) (b)

Figure 2.2 (a) Inboard fishing boats (b) Outboard fishing boats

2.2 The Engine and fuel details

The analysis of the estimation of fishing vessel emission is based on observation of fuel oil consumption from fish catching activity and engine power rating. Table 2.2 shows a statistic of inboard engines and outboard engines for Peninsular Malaysia in 2016. Majority inboard engine in range of 20-39 HP meanwhile majority fishermen equipped their boats with engines in range of 20-39 HP. The emission tests were conducted from both inboard and outboard engines as details out in Table 2.3.

Table 2.2 Number of Licensed Fishing Vessels by Horsepower, 2016 [15]

ENGINES (HP)	INBOARD	OUTBOARD
20-39	820	1370
40-59	65	1001
60-99	209	425
100-149	601	19

Table 2.3 Engine Capacity

Boats	Engine capacity (HP)	Fuel Type
Outboard A	60	Petrol RON 95
Outboard B	90	Petrol RON 95
Outboard C	115	Petrol RON 95
Inboard A	24	Diesel
Inboard B	60	Diesel
Inboard C	113	Diesel

2.3 The Engine and fuel details

The emission level increase proportional to combustion level which indicated by engine load. Engine loading vary according to boat activities. For fishing boat activities, it can be divided into 3 phase as suggested by Ismail [16] and shown in Figure 2.3. Ismail discovered the maximum speed of fishing boats. However, by considering the fact that maximum emission level emitted when the boat at maximum load. Hence, to simulate the boat activities, it is sufficient to run the engine at idle and full throttle.

Turn on the Altair 5x multigas detector by pressing the power button. The user should verify that the alarm LEDs flash, horn sounds briefly and vibrating alarm triggers briefly. Block the pump inlet to perform the pump test. After pump test passed, all the sensors will warm up before measurement can be taken. After all the sensors have been warmed up, set the fresh air setup before performing the carbon monoxide testing. The sampling location shows at Figure 2.4.

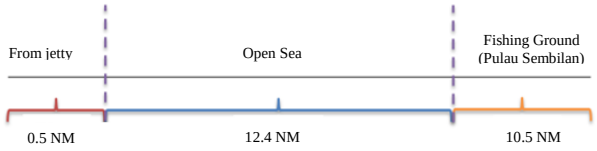
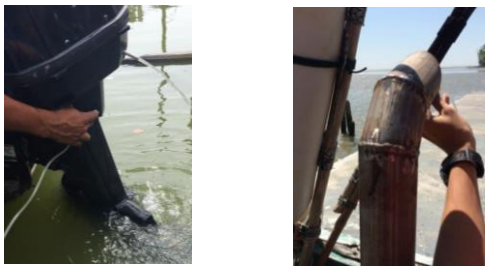


Figure 2.3 Fishing route



(a) (b)

Figure 2.4 Sampling locations at exhaust outlet (a) Outboard (b) Inboard

3. RESULTS AND DISCUSSION

Results of emission were read directly from Altair 5x multigas detector as shown in Figure 3.1 (a) and Figure 3.1(b). Three (3) reading were taken for each engines capacity and represented in Table 3.1

(a) (b)

Figure 3.1 (a) Snapshot of outboard reading (b) Snapshot of inboard reading.

Table 3.1Outboard results

Engine (hp)	Idle (ppm)				Full throttle (ppm)			
	1	2	3	Means	1	2	3	Means
60	1309	1049	2000	1453	2000	2000	2000	2000
90	310	287	286	294	384	382	368	378
115	424	402	382	403	488	507	506	500

Mean for CO emission reading in 60HP engine was recorded as 1453 ppm during idle and increased to 2000 ppm at full throttle. Table 6 shows the results of outboard engines for 60HP, 90HP and 115HP.Similar results from inboard engines were presented in Table 3.2. Based on these table, the graphs are plotted for different engine capacity as shown in Figure 3.2 and Figure 3.3, respectively.

Table 3.2 Inboard results

Engine (hp)	Idle (ppm)				Full throttle (ppm)			
	1	2	3	Means	1	2	3	Means
24	96	88	98	94	370	385	381	379
50	182	207	208	199	333	351	343	342
115	244	254	251	250	288	342	360	330

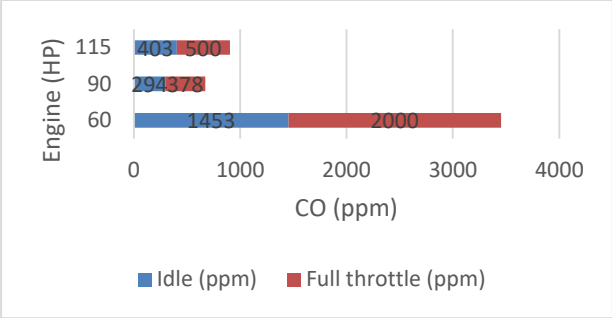


Figure 3.2 Outboard engine carbon monoxide results

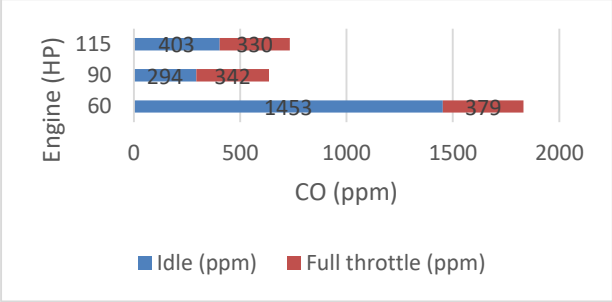


Figure 3.3 Inboard engine carbon monoxide results

As referred from the graph, highest value was recorded by 115 HP engine which about 500 ppm. Meanwhile for inboard engine is about 379 ppm. Comparison between 115 HP outboard engine and 113HP inboard engine has shown major variance in term of CO concentration despite both engines have in range engine size. This is due to difference fuel and engine system were used. The results show that CO value increase proportionally to the engine capacity as more fuel was burn for larger engines power. The power requirement for one particular engine may vary depending on various condition such hoteling, cruise and fishing operation mode. In addition, the quantity of emission produced are much influenced by combustion efficiency, engine condition and engine lifetime. New purchased engine is mostly to give better emission reading than older engine.

4. SUMMARY

Exhaust emission test has been successfully carried out to determine CO gas in Malaysian fishing boats. Portable emission device has shown comparable results with other gas detection instruments. Additionally, it easy to use, less cost, less weight and user friendly. It can be owned by fishermen and this could help them to self-monitor exhaust emission of their boats. Carbon emission data for Malaysia Class A fishing boats will assist authority bodies to monitoring the contribution level of emissions in Peninsular of Malaysia. Sources of emission can be used as decision support for national rule making and for choice of preventive action. Further works will benefit from the data collected by field measurement to generate the new emission factor that will improve the empirical emission estimation for class A fishing boats.

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