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Threats to Food Safety and Sustainability of Nike (*Awaous melanocephalus*) in Gorontalo Province

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Abstract

The objective of this research is to develop the industrial-scale fluid bed dryer for paddy by scale-up of lab-scale experimental data. The developed dryer was conducted by simulation using a two phase model. Firstly, the experimental works by using lab-scale batch fluid bed dryer, was conducted to determine the drying curve of paddy (X_{in} 0.32 kg/kg dry base). In the experimental works, the inlet air temperature was varied (°C): 40; 50; 60. The drying rate curves as a function of moisture content showed only decreasing drying rate period. Then, a very good agreement between the measured and simualtion results of the profile of moisture content in solids was produced by simulator. Finally, a simulated continuous fluidized bed dryer for paddy with dimension 5 m of length and 1.5 of width was succesfully performed, in which the influence of mass solid flow rate 0.1; 0.2; 0.4 tons/h, height of bed 0.25; 0.50; 0.75 m, and air temperature 50; 70; 100 °C on drying process were studied.

Keywords: Paddy, fluid bed dryer, batch, contonious, modelling, simulation.

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1. Introduction

Nike (*Awaous melanocephalus*) seems to have become part of the cultural fabric of society in Gorontalo since time immemorial and perhaps one of the key factors that enable the early development of civilization in this northern part of Tomini Gulf. The myth that tries to explain its very existence is evident to that claim. According to the myth, the fish is the incarnations of an ancestor's menstrual blood which, proved by observations: turns into larvae enclosed in a membrane a size of coconut that drifts from the headwaters to the river mouth where they hatch as the membrane explode into a schooling of billions of juvenile fish.

After becoming the capital of the province in 2001, Gorontalo City grows rapidly. The growth ultimately brings about a diversity of menus into the ever growing food business as well. Nonetheless, varieties of nike dishes often times presented as typical culinary icon become widely renown. In the other hand, its function as important and favorite source of protein for people may be put under threat from the aspects of food safety and sustainable fishery and finally lead into food security issue.

Artisanals and small scale gold mining in Gorontalo has existed since the colonial era. The use of mercury as amalgam with uncontrolled discharge into the river poses high risk of contamination and has been a concern of environment nowadays [1]. One of the most important anthropogenic sources of mercury pollution in aquatic systems is mining [2]. The mining activities in the upper reaches of Bone-Bolango River certainly have an impact on water conditions and organisms in the river and estuary, and eventually to humans who use the water and consume its living organisms. The organic mercury which is known to accumulate in the food chain [3] and cross the blood brain barrier after human ingestion have been causing various neurological effects on human [4, 5]. The threat of inorganic mercury is also severe [6, 7], it is known to be more nephrotoxic than its organic form, as it primarily accumulates in the kidney proximal tubule cells. These are serious threats to human health, in terms of food safety.

Increasing inter-island market demand offers a better economy and stimulates fishermen to increase the catch by increasing capacity of their fishing gear. The fishing gears and methods of fishing systematically greatly reduce the chances of the fish to migrate back to the upstream and continue its life cycle. Therefore, declination and even extinction of nike population due to over fishing is a reasonable fear and will become a real threat in the near future.

This study aims to reveal the extent to which nike's contribution to local food security is threatened from the view point of food safety and sustainability.

2. Materials and Methods

Literature study on *Awaous melanocephalus* is limited. Very few sources discuss this subject. Results of in-depth research about nike cannot be found in scientific journals except for a few that discusses some peripheral aspects about quality, preservation, and processing. Field research was conducted in the estuary of and in the Bone bolango River to observe the technology and methods of nike fishing (Figure 1). Water samples were taken at three stations and examined in April to November 2014. Station 1 is at the river at N00°31'33.5"; E123°03'50.1". Station 2 is on the left side of the estuary at N00°30'08.4"; E123°03'54.5" in front of Leato Village, and Station 3 is on the right side at N 00°29'31.6"; E 123°02'40.9". Both Station 2 and 3 are nike fishing grounds.

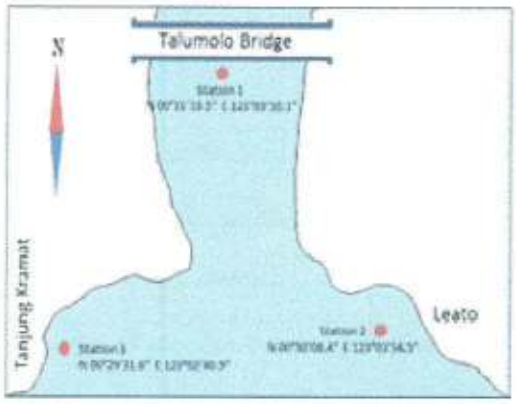

Figure 1: Research site.

Nike samples were taken from fishermen catch on fishing site only at Station 2 in two nike seasons, i.e. the ends of lunar months *Jumadil Akhir* (26th to 28th of April 2014) and *Rajab* (27th to 29th of May 2014). Mercury content examination of water and nike samples were done with Atomic Absorption Spectrophotometer (AAS) variant of 0.5-1000 mg/liter which has a wave length of 283, 3 nm and a slit width of 0.5 nm which was calibrated before use. Examination of mercury content in humans was done by taking hair samples from inhabitants living around the ASGM in the southern part of Gorontalo Province, collected from 77 respondents from Marisa, Tilamuta, Paguyaman and Gorontalo City. The mercury contents in human hair were determined using Particle Induced X-ray Emission (PIXE). Secondary data on production and distribution were obtained from the office of fish quarantine in Gorontalo City.

3. Results and Discussions

3.1. Nike fishery

Nike is classified in Class Pisces; Sub-class Teleostei; Ordo Gobioidea; Family Gobiidae; Genus Awaous; Species *Awaousmelanocephalus* Bleeker [8]. It has transparent, colorless, and scale-less body of 2.5-3 cm length and 3-5 mm depth. Its larvae drift from upstream to the rivermouth and hatch in the sea to form juvenile schoolings. Fish caught at this juvenile stage in the last ten days of lunar calendar and the schooling is of 99% juvenile of *Awaousmelanocephalus* and the rest is juvenile of *Eleotrisfrusca* [9].The juvenile nike migrate or return back to the river of their origin at the end of each capture season before the new moon has risen. In Gorontalo Province, schools of nike are found in certain estuaries, which is in the local language called *milango*. At least there are four estuaries: Milango Taludaa, Milango Hulondalo, Milango Paguyaman, and Milango Marisa (Figure 2). Milango Hulondalo which is the Bone bolango River'sestuary in Gorontalo City has the biggest and steadiest stock.

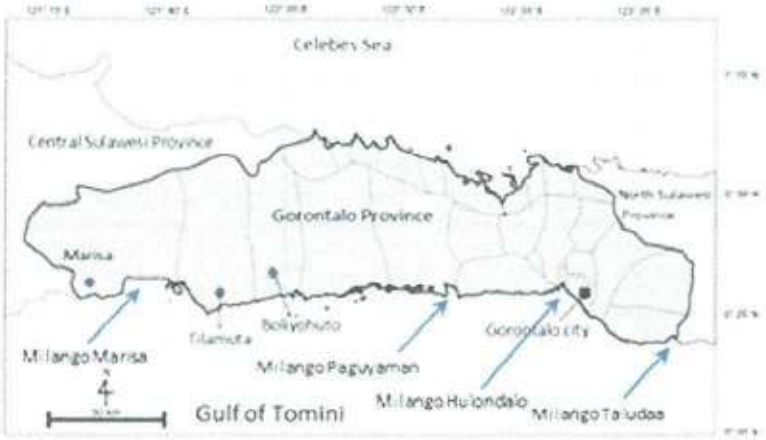

Figure 2: Habitats of nike in Gorontalo Province.

Generally, fresh catch sold by itinerant vendors without proper handling to maintain quality. Without preservation the fish can only stay fresh for 2-3 hours. Stock to be sold the next day preserved with low temperature using cold water to maintain freshness. Nevertheless, its quality degraded and the price declines. The fish has a pale appearance due to physical stress during handling and delays in handling. Cooling treatment using insulated cool box with a ratio of bulk ice and nike 1:2 extends selling period to 10 hours and for ratio 1:1 extends to 20 hours [10]. Nike is consumed freshly and cooked for dishes such as nugget, *yilepao* (sago mixed with nike), *pepes* nike (grilled in banana leaf), and stir-fry. Dried nike is processed with traditional way by the people [11]. There are differences in levels of protein contents in nike that caught in the first day and that of the last day [12]. The protein content in the first day nike is 2.7315%, while in the last day nike is 4.083%. Nike is known to contain essential amino acids like leucine (1.153%) and lysine (0843%), also contains DHA (14.81%) and oleic acid (8.5%) [9].

There are several kinds of tools and methods used to capture nike which undergo changes and improvements over time. When nike is abundant in the waters and gathered in the shallow rocks, people living nearby catch the fish easily by hand or with a simple hand net. A handy lift-net made of two arms of bamboo or wood crossed at the ends into a triangle frame called *dudoyohu* is used for bigger catch. *Dudoyohu* is put in shallow water by laying its net to the bottom with stones as sinkers while the bamboo frames stay afloat. Light is placed on the frame when operates at night (Fig.3a). *Dudoyohu* can also operate on a small canoe by one or two fishermen, a petromax usually used for lighting (Fig.3b).

Larger fishing gear called *tagohu* which is a kind of pocket trawl with a very fine mesh size that operates on shallow waters by two fishing boats and can also operate from shore line like a beach seine by circling and bracketing capture technique. At night operation, another boat for lighting is used to attract nike gathered in front of the net.

Figure 3: Fishing gears to capture nike.

One or two boats herding the fish to enter the pocket while the trawl is hauled slowly to shrink the space until the schooling stuck in. The two boats at either end of the fishing gear haul the bottom straps line to pull the net from opposite directions so that the two boats get closer and finally raised the pocket and collect the catch.

Size and thus catching capacity of *tagahu* has been increasing lately. The smaller *tagahu* that operates in waters of a depth of human knee and the middle size that operates in waters to 15m depth now are exceeded by that operates with bigger boats at depths beyond (Figure 3c). Attempt of fishermen to increase their catching capacity follows the increasing export demand after domestic shipping and processing.

According to a report released by Marine and Fishery Office of Gorontalo Province in 2011 that nike production in the year 2009 was 181 tons. Since nike found a way to inter-island marketing, production and distribution fluctuate in the last six years. Based on distribution data from Fish Quarantine Station, amount of nike shipped inter-island raised in 2010 and then in three years period until 2012 decline to a quarter of the figure (Figure 4). Dramatic increase in shipping again took place in 2013 exceeding the previous rise about one third and then follow a same pattern of decline until August 2015. Seems that the fluctuation occurs in each of the three years periods with a total of 24% increase is apparent between the periods.

What made possible of increases and what caused the declines are not clear. Certainly, demand always induces production while resources, technical and natural constrains slow it. Extensive and in-depth researches are necessarily what we need to understand nike comprehensively in Gorontalo and other similar species nationwide.

3.2. Mercury contamination

Mercury contamination as a threat to food safety of nike is related to the environment where nike live, i.e.the water in its habitat, mercury contents in the fish itself, and mercury accumulation in human body who consume the fish. Therefore, this research attempts to have a clear figure on mercury contents in those three items: the water, the nike, and the human hair.

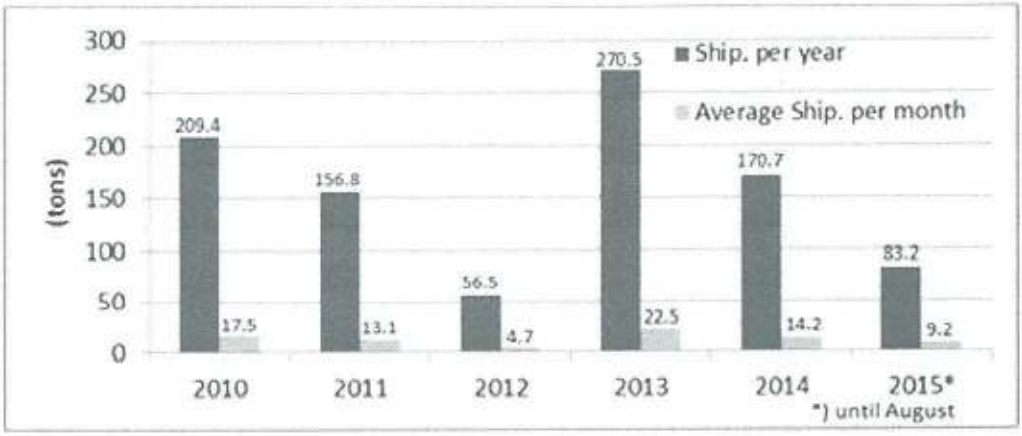

Figure 4: Inter-island shipping of nike from Gorontalo.

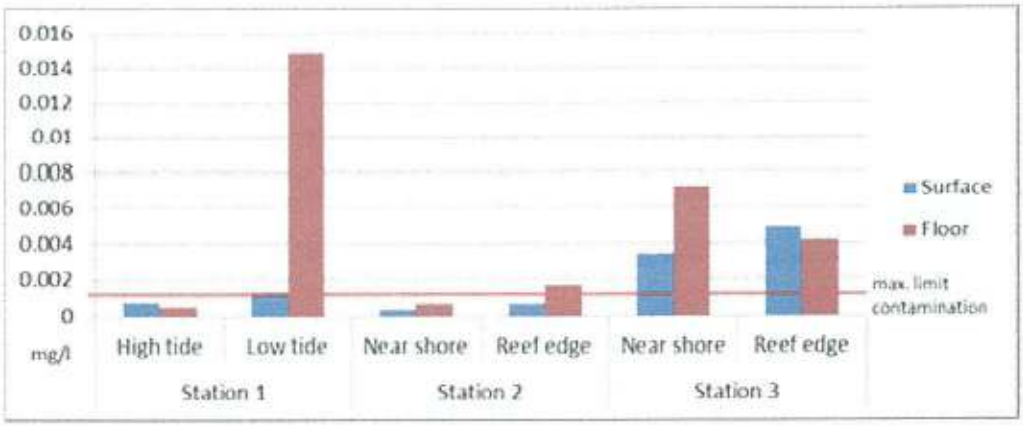

Figure 5: Mercury contamination in water.

3.3. Mercury concentration in water

Results of measurement of samples from water in three stations is given in Figure 5. When compared with the standard value of mercury (Hg) maximum levels allowed under Government Regulation No.82-2001 on the Management of Water Quality and Water Pollution Control and Decree of the Ministry of Environment No. 51-2004 that levels of Hg that is allowed is 0,001 mg/l. The levels of Hg in the waters around the mouth of Bone-Bolango River (Station 1) at low tide already exceed the maximum limit of contamination, especially at the floor. At high tide levels of Hg either at the surface or at the floor are still in good condition as the body of water of the river formed by water that comes from the sea, while at low tide the water in the river is mostly coming from upstream.

The content of Hg at nike fishing grounds (Stations 2 and 3) in waters near shore and at the reef edge varies. At Station 2 sub-station near shore levels of Hg in the surface and the sea floor still far below the maximum limit. At Station 2 sub-station near the

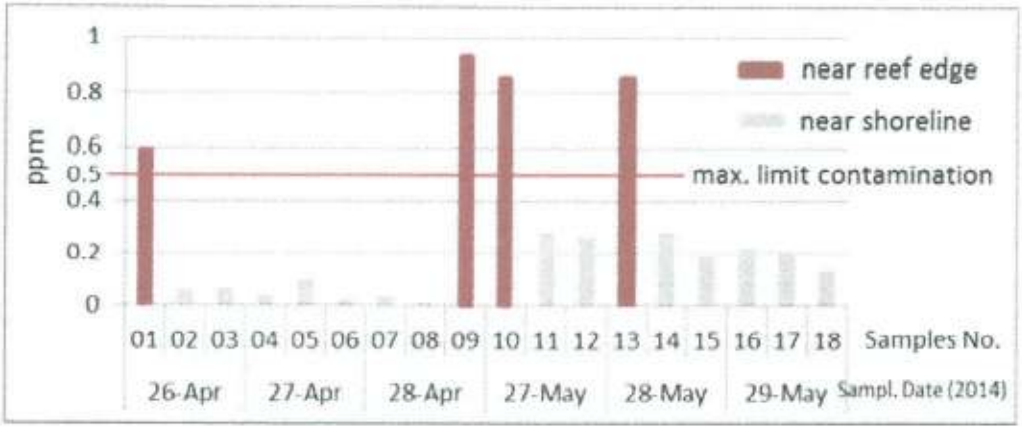

Figure 6: Mercury contamination in nike captured in Station 2 near reef edge and near shoreline.

(sample no.10: 0.8604 ppm) and May 28 (sample no.13: 0.8645 ppm) of the eighteen samples taken within six days. This illustrates that the levels of mercury in nike is not influenced by date of capture and duration of submerged in water. Content of mercury is not uniformly in all samples. Of the three samples taken on the same date when high contamination occurs there is only one sample has high mercury content.

The high level of mercury contamination seems to be strongly related to the spot where nike is captured. Samples with high mercury level are those taken at near the reef edge, contaminated far exceeding the maximum limit contamination of mercury in food permitted by the Indonesia National Standard (SNI 7387:2009) which is 0.5 ppm. Samples taken near the shoreline are all at low level of contaminations.

What causes high levels of mercury in the nike captured near the reef edge is still poorly understood. Content of mercury in the water samples taken at the sea floor near the reef edge at the nike fishing ground in Leato is 0.0017 mg/l, way higher than those of other spots in the same station and exceeding the water quality standard which permits only 0.001 mg/l as imposed by the decree of the ministry of environment (KEPMENLH No.51, 2004). This seems to provide some reason on why the mercury content in the samples taken near the reef edge are higher. Heavy metal like mercury tends to bind organic matters and subsides to the sea floor along with sediment therefore heavy metals content is higher in the water at the sea floor compare with heavy metal content in surface water. Mercury gets into fish through respiration, digestion or skin penetration [14]. Mercury that enters organism cannot be digested and it dissolves in fat therefore it can penetrate cell membrane and accumulate at cells in the organs of the organisms.

3.5. Mercury concentration in human hair

Biological monitoring is intended to detect the changes occurring in human body as a result of the influence of the industrial environment. The human hair as one of the biological samples, has some advantage compare to the other biological sample. Mercury concentration in hair sample will be used to characterize the risk by compared with reference values published by the German Human Biomonitoring (HBM) Commission [22]. HBM divides the risk category related to mercury in hair into 3 levels: Below HBM I (normal) for 0-1 ppm; Between HBM I and HBM II (Alert) for 1-5 ppm; and Over HBM II (High level) for >5 ppm.

Data collected in this research represent hair mercury contamination of inhabitants and ASGM workers of southern part of Gorontalo Province. The southern part of Gorontalo Province comprises large area and distributed into several regencies and city as shown in Figure 2. There are several ASGM (namely Gunung Pani of Marisa, Bilato of Boalemo, Paguyaman of Gorontalo, and Tulabolo of Bonebolango). There is no ASGM in Gorontalo city, but there are many gold shops that also uses mercury that released to Bone bolango River and there was reports on Gold shops contamination [21].

Human hair samples were taken from 77 participating miners and inhabitants who have range of age from 8 to 75 years. About 10-20 strands of hair were cut close to skin from right backside (mastoidal region of the temporal bone) and then labeled and stored in sample plastic bag [23]. Samples were distributed into four main groups according to their living area. The Group of UNG is composed of teachers and students of State University of Gorontalo. UNG Group represents as control group since they do not interact with mining site directly. While others groups represent as group of inhabitants and ASGM workers. The environmental conditions between those groups were different in number of mercury used and etc., but their geometrical means of group of Marisa, Paguyaman and Tilamuta were close to each other. More interestingly none of Tilamuta group work as ASGM workers.

According to HBM the hair mercury concentration more than 1 ppm is already in alert level. It means all of samples of Marisa, Paguyaman and Tilamuta are already in alert level. The UNG group in average also showing the alert level conditions, with exception of some students showing zero level of mercury in their hair. The cases of Tilamuta and UNG groups indicate that people who are not directly interact with mining activities are also put into high risk of mercury contamination through food chain and exposure to contaminated water. Nike, as favorite source of protein in Gorontalo, serves as feeder to higher organisms in the food chain will ultimately or directly deliver the mercury to human being.

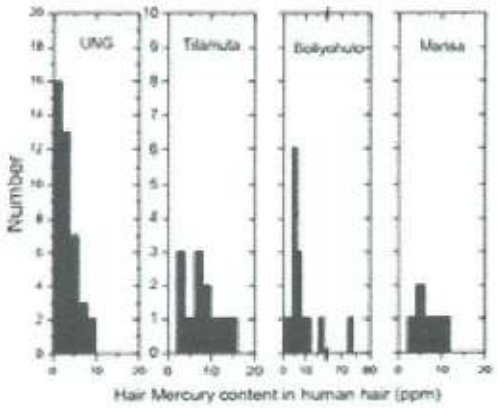

Figure 7: Distribution of Hair mercury content in human hair in southern part of Gorontalo Province.

4. Conclusion and Suggestion

Improving catching capacity of nike fishing gears may boost productivity and increase fishermen's income but that will threat the sustainability of nike fishery if proper measure is not taken. Excessive catch of nike will reduce the chance of the fish to complete their lifecycle thus nike stock will undergo degradation over time. The increasing inter-island demand on nike has to be answered wisely by considering sustainability.

Mercury contamination in the water, nike, and the human being brings about a concern on food safety. The threat will become apparent in near future and the issue will extend to the level of food security as mercury contaminant accumulate excessively in other marine biota consumed by human, spread to staple plants in the watershed of Bone-Bolango River, and permeate in drinking water supply of the surrounding cities.

Comprehensive and in-depth research on *Awaous melanocephalus* is a necessity to address the issue of food safety, food security, and the sustainability of nike fishery.

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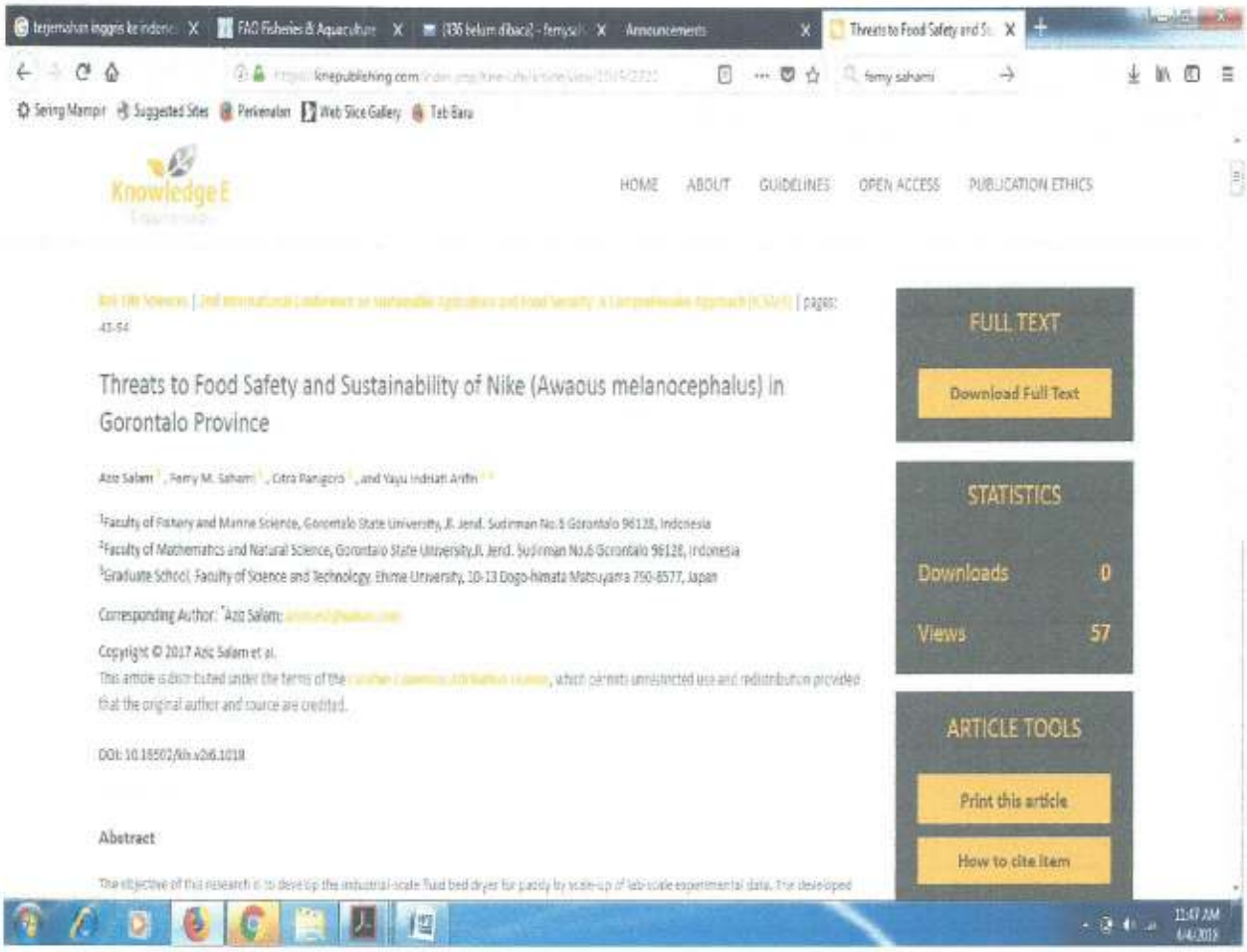

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