Korespondensi Artikel dengan Judul

Profile of volatile organic compounds in kepah (Polymesoda erosa Solander, 1786) collected from Jada Bahrin River of Bangka Island, Indonesia

On Thursday, August 11, 2022 at 09:59:13 AM GMT+3, adec kurnia <andri_pangkal@yahoo.co.id> wrote:

Dear, Tudor Papuc.

I am andri, from Indonesia.
I would like to ask about submission an article to AACL Bioflux journal.
May I send the article via your email?

Thank you for information

Regards,

Andri

Tudor Papuc <ptudor2008@yahoo.com>
Kepada:adec kurnia
Sab, 13 Agu 2022 jam 02.58
Yes, if you wish, you can make the manuscript submission directly to me, on this email address.
In addition to the manuscript, you will also need to send me a submission letter, signed by all the authors (see attachment).

Thank you for considering our journal.

Best Regards,
Tudor Păpuc
Editor, Bioflux

On Saturday, August 13, 2022 at 01:54:36 AM GMT+3, adec kurnia <andri_pangkal@yahoo.co.id> wrote:

Dear Editor
Tudor Păpuc

Let me submit our manuscript for AACL Bioflux Journal. We hope this manuscript contribute to knowledge about volatile organic compounds (VOCs), and it will be accepted and published in AACL Bioflux Journal.

Best Regards,

Andri

Pada Senin, 15 Agustus 2022 16.07.01 WIB, Tudor Papuc <ptudor2008@yahoo.com> menulis:

I have received the manuscript.

Before accepting the submission for the preliminary evaluation, you need to expand the Material and Method section and be more specific there:
- how many samples you collected from each (kepah, water, sediment); what quantity of samples; how you collected samples; when exactly were the samples collected; how was the habitat from where the samples were collected; how you stored and prepared the samples for analysis;
- detail the exact parameters used for Pyrolysis Gas Chromatography–Mass Spectrometry (pyr-GC/MS)

So, after you rewrite the Material and Method section, please resend me the manuscript.

Thank you,

Best Regards,
Tudor Păpuc
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On Tuesday, August 16, 2022 at 11:51:44 PM GMT+3, adec kurnia <andri_pangkal@yahoo.co.id> wrote:

Thank you for the preliminary evaluation.
We resend the manuscript for you.

Best Regards
Andri

Pada Kamis, 18 Agustus 2022 16.13.49 WIB, Tudor Papuc <ptudor2008@yahoo.com> menulis:

Thank you, the paper can now enter the preliminary evaluation.

Best Regards,
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Pada Jumat, 7 Oktober 2022 21.31.38 WIB, Tudor Papuc <ptudor2008@yahoo.com> menulis:

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Your paper is accepted for publication. Please find attached the acceptance letter.
After this acceptance you should pay 300 USD for publication (open access-priority processing).
As the payment and bank transfer may be time consuming you may start the process of payment right now; we will send you the invoice immediately after the payment.
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Thank you for publishing with us!

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Tudor Papuc
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On Friday, October 14, 2022 at 05:06:04 AM GMT+3, adec kurnia <andri_pangkal@yahoo.co.id> wrote:

Dear Tudor Papuc.

Let me send a bank payment slip for our publication fee of article **Profile of Volatile Organic Compounds in Kepah (*Polymesoda erosa* Solander, 1786), Collected from Jada Bahrin River of Bangka Island, Indonesia.**

We have transferred USD 300 via Bank Mandiri of Indonesia to Bioflux SRL (Banca Transilvania).
We hope you can check it and you want to confirm us about it.

Thank you
Best Regards,
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On Sunday, October 16, 2022 at 12:10:09 AM GMT+3, Tudor Papuc <ptudor2008@yahoo.com> wrote:

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I am continuing with the processing.

Best Regards,
Tudor Păpuc
Editor, Bioflux

Pada Selasa, 25 Oktober 2022 18.27.30 WIB, Tudor Papuc <ptudor2008@yahoo.com> menulis:

Hello, I am back with the paper with comments. What you need to do is this:
1. Read all the paper carefully, because the English was corrected and the text was formatted.
2. Read carefully all the comments first (before starting the corrections, because some comments might relate to each other) and try to correct as best as you can. **Please work on this version of the manuscript. Please mark your changes (highlight with yellow, or use track changes; you can also leave the comments), so I can check them**. If you cannot correct, do not wish to do so, or have your own explanations, please write the reason as a reply to the comment or as a new comment.
3. If you have anything to add/change to the text not based on comments, please do so, but mark the changes like in point 2.
4. Try to respect the formatting when making changes.
5. After you make the corrections, please check again, to make sure everything is in order.
6. Send me back the corrected version of the manuscript.
I will check it, give it a final form, and send you the final version for a last check before publication.
Thank you,

Best Regards,
Tudor Păpuc
Editor, Bioflux

On Wednesday, October 26, 2022 at 01:26:37 PM GMT+3, adec kurnia <andri_pangkal@yahoo.co.id> wrote:

Dear, Tudor Păpuc.

We have revised our manuscript based on your comments.
We mark a highlight (yellow) in our new revision of the manuscript and we also add some comments at balloon comment to explain some notes.

We hope you can check it.

Thank you

Best Regards,
Andri

Pada Rabu, 26 Oktober 2022 19.39.31 WIB, Tudor Papuc <ptudor2008@yahoo.com> menulis:

The changes are accepted. Please find the final version of the paper.

Please add the postal code to the addresses (in the text after the references) and read the paper again carefully.

If you have other changes, make them, but mark the changes as you did before. Please note that we cannot change anything after publication. Regarding the tables, they might suffer small position movement to fit better on page.

So, after you send me back the manuscript, I will also check it again and publish it in 1-3 days, and will let you know afterwards.

Thank you,

Best Regards,
Tudor Păpuc
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On Friday, October 28, 2022 at 12:15:15 AM GMT+3, adec kurnia <andri_pangkal@yahoo.co.id> wrote:

Dear, Tudor Păpuc.

We did some changes on our paper and we marked it with "green". Thank you so much.

Best Regards,
Andri

Pada Sabtu, 29 Oktober 2022 05.36.39 WIB, adec kurnia <andri_pangkal@yahoo.co.id> menulis:

Thank you Tudor Păpuc

Best Regards,
andri

Pada Sabtu, 29 Oktober 2022 03.07.20 WIB, Tudor Papuc <ptudor2008@yahoo.com> menulis:

Congratulations! The manuscript is published!
You can find it here, on our site: http://www.bioflux.com.ro/docs/2022.2597-2608.pdf or in the attachment below.

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Thank you for publishing with us!

Best Regards,
Tudor Păpuc
Editor, Bioflux

On Sunday, October 30, 2022 at 03:07:03 PM GMT+2, adec kurnia <andri_pangkal@yahoo.co.id> wrote:

Dear, Tudor Păpuc

Please forgive me
We look at footer, we can't find the year, volume, and issue "AACL Bioflux, 201X, Volume X, Issue X".
Is it correct?

thank you for your information.

Best Regards,

andri

Tudor Papuc <ptudor2008@yahoo.com>
Kepada:adec kurnia
Sen, 31 Okt 2022 jam 14.59
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We have performed the change. Find here the
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Profile of volatile organic compounds in kepah (*Polymesoda erosa* Solander, 1786) collected from Jada Bahrin River of Bangka Island, Indonesia

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[1] Department of Fisheries Resources Management, Faculty of Agriculture, Fishery, and Biology, University of Bangka Belitung, Bangka, Indonesia; [2] Department of Aquaculture, Faculty of Agriculture, Fishery, and Biology, University of Bangka Belitung, Bangka, Indonesia. Corresponding author: A. Kurniawan, andri_pangkal@yahoo.co.id

Abstract. This study aimed to provide information about the profile of volatile organic compounds (VOCs) in kepah (*Polymesoda erosa* Solander, 1786), and also about sediment and water of their habitat in Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia. The analysis of VOCs was carried out using Pyrolysis-GC/MS analysis. A number of volatile organic compounds (VOCs) were measured, including aldehydes, alcohols, aromatic compounds, carbohydrates, carbon dioxide, esters, hydrocarbons, ketones, nitrogenous compounds, oxygen-sulfur compounds, and proteins. We have found that 29 VOCs were detected in kepah meat. Hexadecanoic acid (CAS) (palmitic acid) had the highest concentration, 14.04%. We also found 28 VOCs in the water. Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-dibromo-2-chlor had the highest concentration, namely 19.41%. Furthermore, there were 60 VOCs that detected in sediment, with the highest concentration for 1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene (6.36%).
Key Words: clam, degradation, organic chemical, pyrolysis-GC/MS.

Introduction. The volatile organic compounds (VOCs) are large groups of organic chemical compounds found in many products of life. They vaporize easily and enter the environment under normal conditions (Yadav & Pandey 2018). VOCs are defined by the US Environmental Protection Agency (U.S. EPA), as organic compounds with low initial boiling point (less than or equal to 250°C) at a standard atmospheric pressure of 101.3 kPa (Cheng et al 2019). Wang et al (2018) define VOCs as volatile organic compounds with higher saturated vapor pressure (greater than or equal to 0.01 kPa at 20°C), low boiling point, and small molecular weight. The VOCs include into non-methane hydrocarbons such as alkanes, alkenes, alkynes and aromatic hydrocarbons (NMHCs), oxygen containing organic compounds including aldehydes, ketones, alcohols, ethers and halogenated hydrocarbons (OVOCs), nitrogenous compounds, sulfur compounds and other compounds.

The VOCs are ubiquitous in the environment and they may represent health risks. The VOCs are derived from natural and human activities or anthropogenic sources. Naturally, VOCs can be produced by macroalgae in response to environmental stresses and also from plants. VOCs generated by anthropogenic activities come from both domestic and industrial processes (Bravo-Linares et al 2010; David & Niculescu 2021). Since the industrial waste around the river could contain some hazardous VOCs that might affect the health of living organisms in the water and can enter the human body via food chain pathways. They can lead to symptoms and pathologies in the respiratory tract, nervous system, skin, kidneys and others. Some VOCs like benzene, 1,3-butadiene, and vinyl chloride are classified by the International Agency for Research on Cancer (IARC) in Group 1 as carcinogenic for humans (Juang et al 2009; Montero-Montoya et al 2018). On the other hand, VOCs in foods provide a flavor fingerprint that help humans recognize appropriate foods and avoid poor or dangerous foods (Dini 2008). The group of VOCs such as ethyl esters, aldehydes, nitrogen compounds, ketones, alcohols, and dimethylsulphone, represent the main aromatic constituents of foods (Genovese et al 2019). Thus, it is important to understand their presence in the environment and especially in our diet and to identify possible sources of VOCs (Vinci et al 2015).

Argente (2016) explains that there are three genera within the Family Corbiculidae, which are distributed worldwide, namely *Batissa*, *Polymesoda*, and *Corbicula*. Hamli et al (2015) explain there are three common species of the genus *Polymesda* from the family Corbiculidae, class Bivalvia that can be found inhabiting the mangrove areas in Southeast Asia, namely *P. erosa*, *P. bengalensis*, and *P. expansa*. The mud or mangrove clam (*Polymesoda erosa* Solander, 1786), with the local name 'kepah' in Bangka Island, is an edible bivalve species. *P. erosa* can be found in intertidal areas, in mangrove substrate and in the fresh and brackish waters of mangrove swamps, estuaries, and larger rivers (Biona et al 2017). Molluscs have high economic value and reproduce easily. In addition, they are highly nutritious and are considered an excellent source of proteins, lipids and minerals. Molluscs are a highly valuable aquaculture resource, and mussels in particular are typical filter feeders, constantly filtering substances out of the surrounding water (Wang et al 2021). *Polymesoda* sp. feed by filtering suspended particles in the water that surrounds them (Mustapha 2020). Bivalves are well known as filter feeders for suspended particles within water columns that may be contaminated with numerous pollutants from anthropogenic activities or natural factors (Yusoff et al 2021). Therefore, they can be a potential source of organic and inorganic environmental pollutants that accumulate in the body and are transmitted to humans through consumption (Ding et al 2021; Mutić et al 2021).

This study aimed to provide information related to the volatile organic compounds from the meat of kepah, sediment and water collected from Jada Bahrin River, Bangka Regency, Bangka Island, Indonesia.

Material and Method. This research took place from May to June 2022. The study was conducted by testing volatile organic compounds from samples (kepah, sediment, and water), collected from Jada Bahrin River, located in Bangka Regency, Bangka Island, Indonesia. We have sampled randomly 20 individuals of kepah, 1.5 L of water, and 100 g of sediment. The habitat of kepah in the area of sampling was represented by the mud around mangrove trees. The identification of kepah was done using as reference www.sealifebase.ca. Collected samples were stored in a cold box with at less than 5^{o}C to prevent the decrease in VOC content. Kepah (0.05 mg), sediment (0.05 mg), and water of river (0.05 mg) were used as samples in this study.

The VOCs were determined using Pyrolysis Gas Chromatography–Mass Spectrometry (pyr-GC/MS) (Peters et al 2018; Bouzid et al 2022). Patoni et al (2022) explain that qualitative and quantitative analysis of volatile compounds was measured using the GCMS Pyrolysis Shimadzu GCMS-QP 2010, with a column length (rt x 5 ms) 60 m, 0.25 mm in diameter and 0.25 m thickness. The initial column oven temperature was held at 50°C for 5 min and increased by 2.5°C min^{-1} to 150°C, and finally with 90°C min^{-1} to 280°C. In pyrolysis, it was set at 600°C. Gas Chromatography was set at a pressure of 101.0 kPa, total flow 46.5 mL min^{-1}, column flow 0.85 mL min^{-1}, with a linear velocity of 23.7 cm sec^{-1}. The ion source temperature and the interface temperature were maintained at 200 and 280°C, respectively, with a split ratio of 1:50 with 1 mL of sample injected. Some VOCs were investigated and presented in chromatograms, while name and retention time (R. time) of total ion chromatography (TIC) was based on peaks of chromatograms. The results of GCMS-Pyrolysis analysis were analyzed and tabulated using the Wiley 7 program.

Results and Discussion. Kepah collected from Jada Bahrin River are presented in Figure 1. 29 VOCs were detected in kepah meat with the highest concentration found at peak 23 with a retention time of 22.975 min for hexadecanoic acid (CAS) (palmitic acid - 14.04%) (Table 1 and Figure 2).

Figure 1. *Polymesoda erosa* from Jada Bahrin River of Bangka Regency, Indonesia; a - collection process; b - kepah after collection; c - kepah in the laboratory.

Table 1
Volatile organic compounds of *Polymesoda erosa* meat from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	7.293	3.47	Nitrogen oxide (N_2O) (CAS) Nitrous oxide
2	7.717	1.76	1,4-oxathiane, 4,4-dioxide (CAS) p-Thioxane sulfone
3	16.138	0.43	2-cyclopenten-1-one, 2-hydroxy-3-methyl- (CAS) Corylon
4	16.723	0.49	Isooctane, (ethenyloxy)- (CAS) Isooctyl Vinyl Ether
5	17.017	0.72	Pentanal (CAS) n-Pentanal
6	17.392	0.40	1,3-pentanediol, 2,2,4-trimethyl- (CAS) 2,2,4-trimethyl-1,3-pentanediol
7	17.640	0.51	Decane, 2,3,5,8-Tetramethyl-
8	18.029	0.53	2-butene-1,4-diol, (Z)- (CAS) cis-Butenediol
9	18.480	0.35	Tetradecane (CAS) n-Tetradecane
10	18.992	0.65	2-undecene, 2,5-dimethyl- (CAS) 2,5-dimethyl-2-undecene
11	19.271	0.61	Pentadecane (CAS) n-Pentadecane
12	19.555	0.61	9-octadecenoic acid (Z)- (CAS) Oleic acid
13	19.767	0.45	Nonadecanol
14	20.017	0.83	Dodecane, 2,6,10-trimethyl- (CAS) Farnesane
15	20.218	1.56	Dodecanoic acid (CAS) Lauric acid
16	20.636	1.79	10-undecenoic acid, octyl ester (CAS) Octyl 10-undecenoate
17	20.892	2.24	Octadecanoic acid (CAS) Stearic acid
18	21.313	2.51	Docosanoic acid (CAS) Behenic acid
19	21.570	5.08	Tetradecanoic acid (CAS) Myristic acid
20	22.011	3.76	Pentadecanoic acid (CAS) Pentadecylic acid
21	22.226	5.34	Pentadecanoic acid (CAS) Pentadecylic acid
22	22.685	3.62	Hexadecanoic acid (CAS) Palmitic acid
23	22.975	14.04	Hexadecanoic acid (CAS) Palmitic acid
24	23.359	5.48	Heptadecanoic acid (CAS) Margaric acid
25	23.639	7.46	Heptadecanoic acid (CAS) Margaric acid
26	24.120	2.83	2(3H)-guranone, 5-dodecyldihydro- (CAS). gamma.-Palmitolactone
27	24.404	8.49	9-octadecenoic acid (Z)- (CAS) Oleic acid
28	24.795	6.29	Hexadecanamide (CAS) Amide 16
29	25.356	3.86	Nonadecanamide

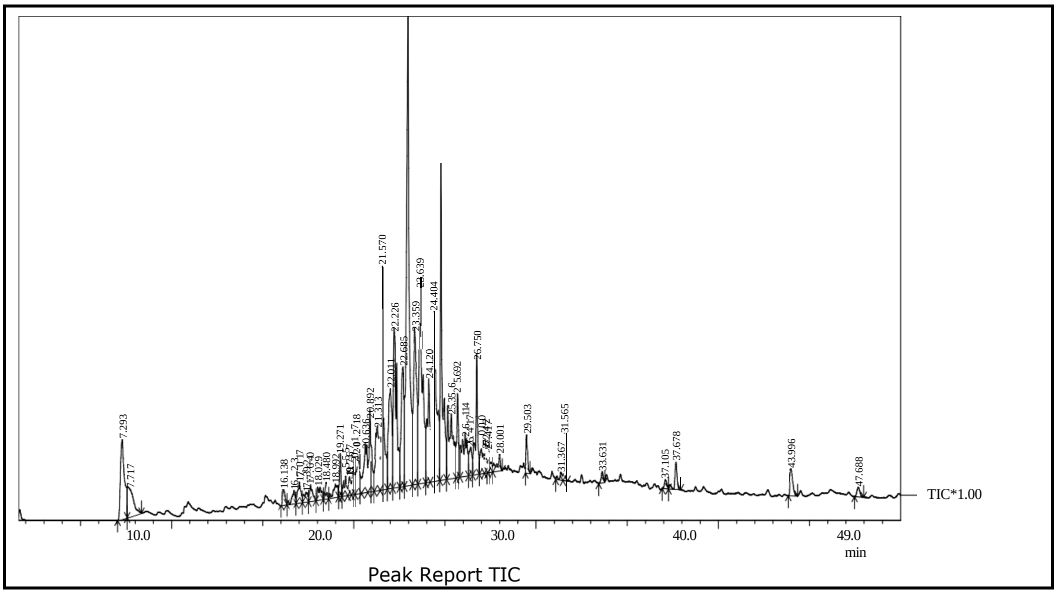

Figure 2. Total chromatogram of *Polymesoda erosa* meat from Jada Bahrin River of Bangka Regency.

In total, 29 VOCs were identified from kepah meat samples. Of these compounds, there were 1 aldehyde, 3 alcohols, 1 aromatic compound (furan), 1 ester, 14 fatty acids, 5 hydrocarbons, 2 ketones, 1 nitrogenous compound, and 1 oxygen-sulfur compound (Figure 3). The fatty acids were the most abundant compounds, including lauric acid, stearic acid, behenic acid, myristic acid, palmitic acid, margaric acid, oleic acid, and derivates such as hexadecanamide and nonadecanamide.

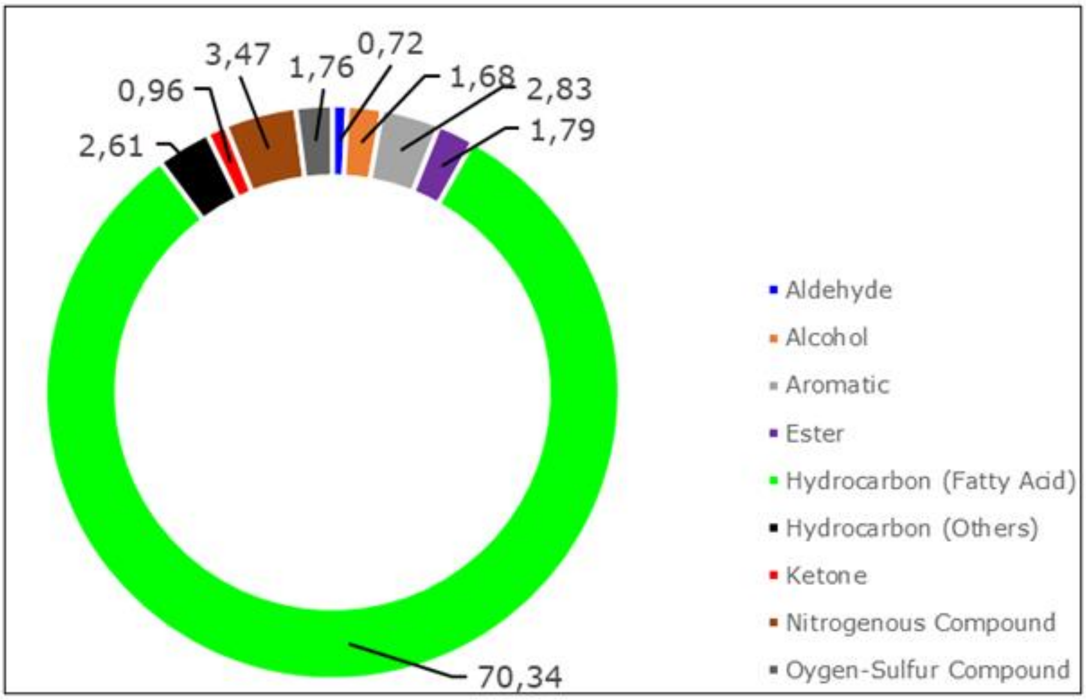

Figure 3. Total volatile compound groups of *Polymesoda erosa* meat.

P. erosa is a mollusc with a great nutritional potential, especially in fatty acids. Some of the saturated fatty acids (SFAs) from *P. erosa* are palmitic acid (C16:0), myristic acid (C14:0), lauric acid (C12:0), stearic acid (C18:0), behenic acid (C22:0), and

pentadecanoic acid (C15:0). Monounsaturated fatty acids (MUFA) are margaric acid (17:1) and oleic acid (C18:1n9c), as found in this research, but also by Leiwakabessy et al (2019). Polyunsaturated fatty acids from *P. erosa* were not found in this study.

We also analyzed VOCs of water from Jada Bahrin River. There were 28 VOCs detected in the water, with the highest concentration found at peak 26 with a retention time of 20.762 min, for 1,6-anhydro-beta-D-glucopyranose (levoglucosan) (24.88%) (Table 2 and Figure 4). Latif et al (2012) explain levoglucosan (1,6-anhidro-β-D-glucopyranose) is an organic molecule that can be used as an indicator for cellulose burning. Thus, it is possible that levoglucosan from filter paper has contaminated the pyrolysis of VOCs.

Of the identified compounds, there were 6 aldehydes, 5 alcohols, 2 carbohydrates, 1 ester, 9 hydrocarbons, 4 ketones, and 1 protein (Figure 5). The hydrocarbons were the most abundant compound in the water. Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-dibromo-2-chlor, was the highest VOC found in the water of Jada Bahrin River, after levoglucan (which was presumed to have contaminated the sample). Cyclopropane belongs to the class of organic compounds known as cycloalkanes, a group of hydrocarbons, found at peak 1 with a retention time of 6.486 min and a concentration of 19.41%.

Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-dibromo-2-chlor is an organic compound found in jabon (*Anthocephalus cadamba*) (Hadi et al 2021) and has antioxidant properties in young agarwood (*Aquilaria malaccensis* Lamk) leaves (Batubara et al 2021). Thus, we did not consider this VOC as a dangerous compound for the environment or for human health.

Table 2

Volatile organic compounds of water from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	6.486	19.41	Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor
2	8.260	3.24	2-methyl-3-oxo-Butyronitrile
3	9.025	0.50	Pentane (CAS) n-Pentane
4	9.412	2.98	Acetic acid (CAS) Ethylic acid
5	9.796	6.17	2-propanone, 1-hydroxy- (CAS) Acetol
6	11.591	0.43	2,3-pentanedione (CAS) 2,3-pentadione
7	11.825	1.07	Propanoic acid, 2-oxo-, methyl ester (CAS) Methyl pyruvate
8	12.179	0.77	1-cyano-6-hydroxypentane
9	12.594	0.53	2-furancarboxaldehyde (CAS) Furfural
10	13.156	0.35	2-propanone, 1-(acetyloxy)- (CAS) Acetol acetate
11	13.325	1.63	2-furanmethanol (CAS) Furfuryl alcohol
12	14.351	1.99	Cyclohexanone (CAS) Anon
13	14.525	1.47	2-furancarboxaldehyde, 5-methyl- (CAS) 5-methyl-2-furfural
14	15.562	1.91	2-cyclopenten-1-one, 2-hydroxy-3-methyl- (CAS) Corylon
15	15.988	1.71	Hydroxy Dimethyl Furanone
16	16.379	5.90	Pentanal (CAS) n-Pentanal
17	16.967	1.82	7-methyl-1,4-dioxaspiro[2.4]heptan-5-one
18	17.196	1.69	1-octene (CAS) Caprylene
19	17.561	2.62	Oxirane, 2-butyl-3-methyl- (CAS) 2,3-epoxyheptane
20	18.046	4.42	2-furancarboxaldehyde, 5-(hydroxymethyl)- (CAS) HMF
21	18.442	1.15	4-heptanol, 2,6-dimethyl-4-(1-methylethyl)- (CAS) 2,6-dimethyl-4-Isopro
22	18.912	3.11	Ethenol, 2-ethoxy-, acetate (CAS)
23	19.392	1.66	L-Glutamic acid, N-[(phenylmethoxy)carbonyl]-
24	19.667	2.52	2-propenoic acid, 2-methyl-, hexyl ester (CAS) Hexyl methacrylate
25	20.075	1.27	1-cyclohexene-1-carboxylic acid (CAS) 1-cyclohexenecarboxylic acid
26	20.762	24.88	1,6-anhydro-Beta-D-Glucopyranose (Levoglucosan)

Peak	Retention time (min)	Concentration (%)	Name
27	21.775	2.44	1,6-anhydro-Beta-D-Glucofuranose
28	22.308	2.36	4-decenoic acid, methyl ester (CAS) Methyl dec-4-enoate

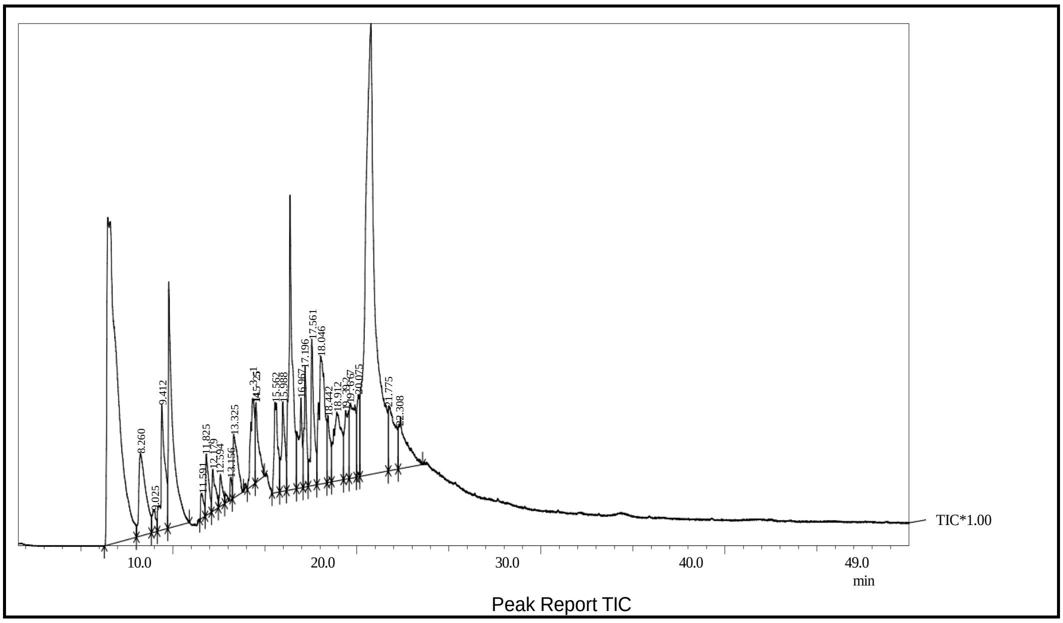

Figure 4. Total chromatogram of water from Jada Bahrin River of Bangka Regency.

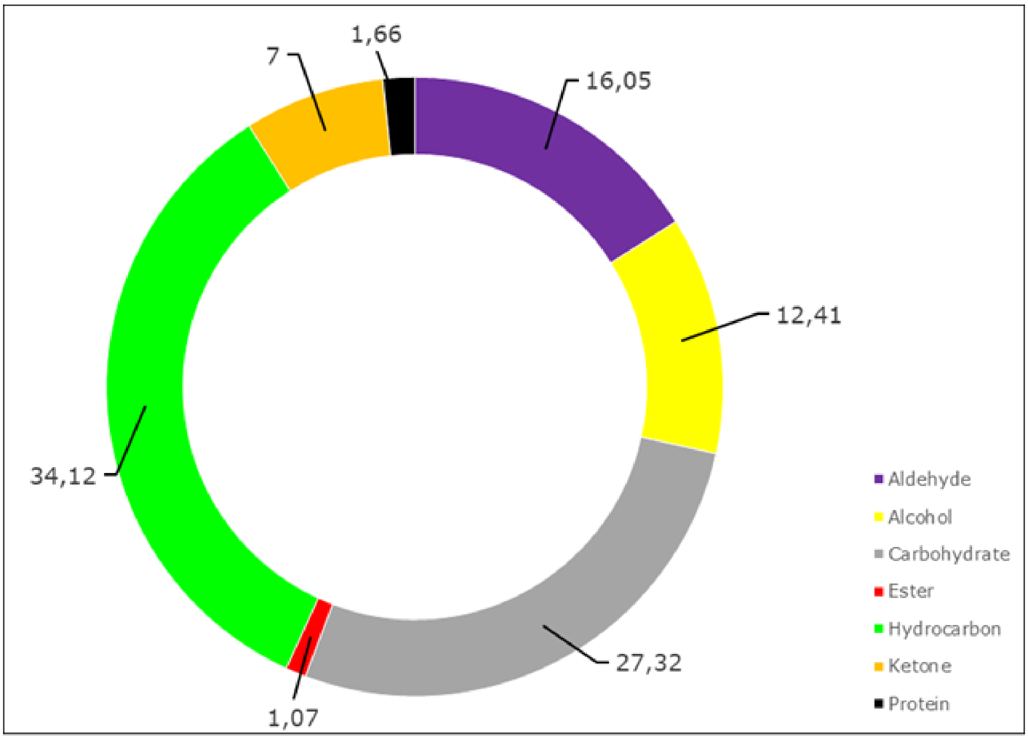

Figure 5. Total volatile compound groups in the water of Jada Bahrin River.

Sixty VOCs were detected in the sediment of Jada Bahrin River, with the highest concentration found at peak 50, with a retention time 41.694 min, for 1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene (6.36%) (Table 3 and Figure 6). Of the identified compounds, there were 1 aldehyde, 4 alcohols, 1 carbon dioxide, 6 esters, 45 hydrocarbons, and 3 ketones (Figure 7). The hydrocarbons were the most abundant compound type in the sediment. We found two VOC hydrocarbons that contain benzene, namely benzofuran, 2,3-dihydro- (CAS) 2,3-dihydrobenzofuran (R. time 18.481 min, 1.48%) and 1H-benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-, (R. time 36.717 min, 0.58%).

Benzene is an aromatic hydrocarbon and a colorless and odorous liquid (Meckenstock et al 2016; Yildizhan et al 2021). It is formed from both natural processes and human activities. It is classified as carcinogen for humans, with effects such as acute leukemia and probably other hematological cancers. Benzene is a major raw material to make plastics, resins, synthetic fibers, nylons, dyes, detergents, pharmaceuticals and pesticides, and is also a component of crude oil (Smith 2010; Conte et al 2021). In the environment, this pollutant can be accumulated in organisms through direct or indirect routes. It is potentially accumulated in filter feeder organisms such as a clams.

Table 3

Volatile organic compounds of sediment from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	7.243	3.58	Carbon dioxide (CAS) Dry ice
2	17.642	0.53	10-undecenoic acid, Octyl ester (CAS) Octyl 10-Undecenoate
3	18.242	0.56	Nonanoic acid (CAS) Nonoic acid
4	18.481	1.48	Benzofuran, 2,3-dihydro- (CAS) 2,3-Dihydrobenzofuran
5	18.992	0.66	Decanoic acid (CAS) Capric acid
6	19.268	0.70	1-Octanol, 2-butyl- (CAS) 2-Butyl-1-octanol
7	19.492	0.32	2-Butanone, 4-cyclohexyl- (CAS) 4-Cyclohexyl-2-butanone
8	19.817	0.75	(1R*,6S*,10R*)-5,5-dimethyl-11,12-dioxatricyclo[8.2.1.0(1,6)]tridecan-10-ol
9	20.009	0.66	Hexadecane (CAS) n-Hexadecane
10	20.337	1.04	Docosanoic acid (CAS) Behenic acid
11	20.713	0.87	Tricosane (CAS) n-Tricosane
12	20.941	1.28	3-Hexadecene, (Z)- (CAS)
13	21.541	2.79	9-octadecenoic acid (Z)- (CAS) Oleic acid
14	21.867	0.47	2-undecanone, 6,10-dimethyl- (CAS) 6,10-dimethylundecan-2-one
15	22.067	2.35	Tetratetracontane (CAS) n-Tetratetracontane
16	23.015	4.98	Oxacycloheptadec-8-en-2-one (CAS) Ambrettolide
17	23.446	0.88	Pentatriacontane (CAS) n-Pentatriacontane
18	23.667	0.59	Megastigma-3,7(Z),9-triene
19	24.197	1.34	Pentatriacontane (CAS) n-Pentatriacontane
20	24.621	1.55	Oxacycloheptadec-8-en-2-one (CAS) Ambrettolide
21	25.026	1.16	Octadecane, 1-chloro- (CAS) 1-chlorooctadecane
22	25.974	0.40	Pentatriacontane (CAS) n-Pentatriacontane
23	26.891	0.69	Cyclododecanone (CAS) Cyclododecanon
24	27.067	0.37	Hexatriacontane (CAS) n-Hexatriacontane
25	27.973	0.60	1,2-Propanediol, 3-(Phenylmethoxy)-, Diacetate
26	28.388	0.52	Pentatriacontane (CAS) n-Pentatriacontane
27	29.667	1.22	Tetrapentacontane, 1,54-dibromo-
28	29.966	1.79	Tetratetracontane (CAS) n-Tetratetracontane
29	31.909	1.39	Pentatriacontane (CAS) n-Pentatriacontane
30	32.567	1.98	1-Hentetracontanol (CAS) N-Hentetracontanol-1
31	32.790	0.82	6-O-acetyl-7-desoxy-1,2:3,4:8,9:11,12-tetra-O-isopropyliden-7-nitro-.beta.-D-
32	33.117	1.05	Methyl Commate E
33	33.688	3.97	Nonacosanol (CAS)
34	34.060	1.81	Hexacosane, 9-octyl- (CAS) 9-n-Octylhexacosane
35	34.303	1.11	Pentatriacontane (CAS) n-Pentatriacontane
36	34.920	2.67	9,19-Cyclolanost-24-en-3-ol, Acetate
37	35.438	0.65	2-Pentadecanone, 6,10,14-trimethyl- (CAS) 6,10,14-Trimethyl-

Peak	Retention time (min)	Concentration (%)	Name
			2-pentadecano
38	36.269	5.36	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy)trimethyl- (CAS) Cycl
39	36.717	0.58	1H-Benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-,
40	36.999	3.43	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy)trimethyl- (CAS) Cycl
41	37.474	1.18	Cycloeucalenol
42	37.817	1.48	Nonacosanol (CAS)
43	38.368	0.70	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy) trimethyl- (CAS) Cycl
44	38.590	0.79	Androst-5-en-3-ol, 4,4-dimethyl-, (3.beta.)- (CAS)
45	39.044	1.50	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
46	39.550	1.20	Cycloeucalenol
47	40.053	1.78	Androst-5-en-3-ol, Trifluoroacetate, (3.beta.)- (CAS)
48	40.639	2.68	13,27-Cycloursan-3-ol, Acetate, (3.Beta.,13.Beta.,14.Beta.)-
49	40.942	0.97	Tetracosane, 11-decyl- (CAS) 11-n-Decyltetracosane
50	41.694	6.36	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
51	42.132	3.08	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
52	42.629	3.31	4,4,6A,6B,8A,11,11,14B-octamethyl-1,4,4A,5,6,6A,6B,7,8,8A,9,10,11,12,
53	43.051	1.01	Norolean-12-ene
54	43.841	0.67	4,4,6A,6B,8A,11,11,14B-octamethyl-1,4,4A,5,6,6A,6B,7,8,8A,9,10,11,12,
55	44.417	0.57	9,19-cyclolanost-24-en-3-ol, Acetate
56	44.867	5.70	9,19-cyclolanost-24-en-3-ol, (3.beta.)- (CAS) Cycloartenol
57	45.517	0.68	Pentatriacontane (CAS) n-Pentatriacontane
58	45.828	2.30	6-isopropenyl-4,8A-dimethyl-3,5,6,7,8,8A-Hexahydro-1H-Naphth
59	46.399	1.22	9,19-cyclolanost-24-en-3-ol, (3.beta.)- (CAS) Cycloartenol
60	47.407	3.86	14-.Beta.-H-Pregna

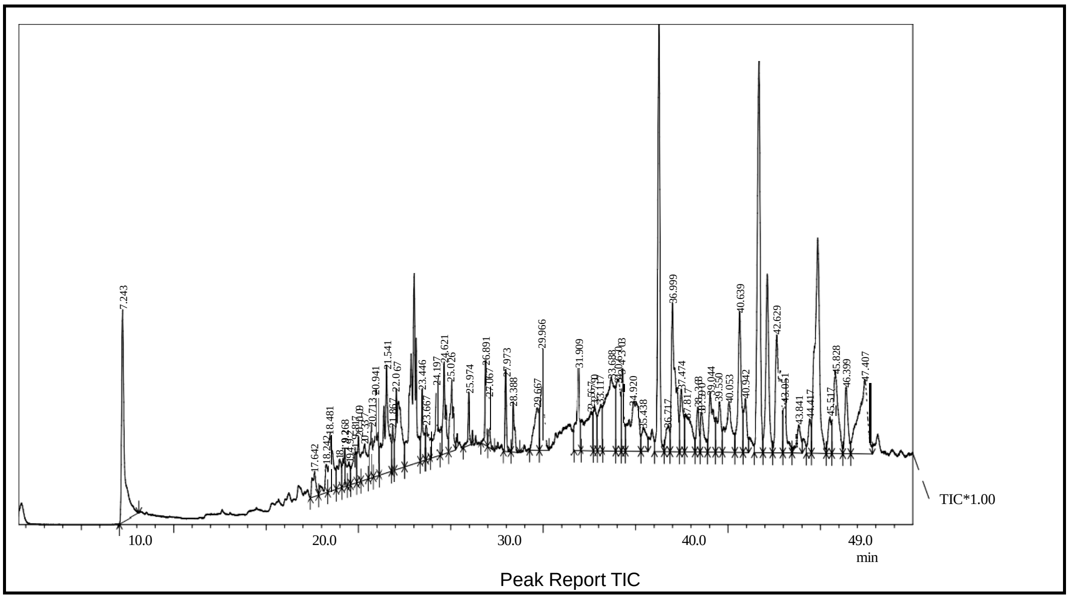

Figure 6. Total chromatogram of sediment from Jada Bahrin River of Bangka Regency.

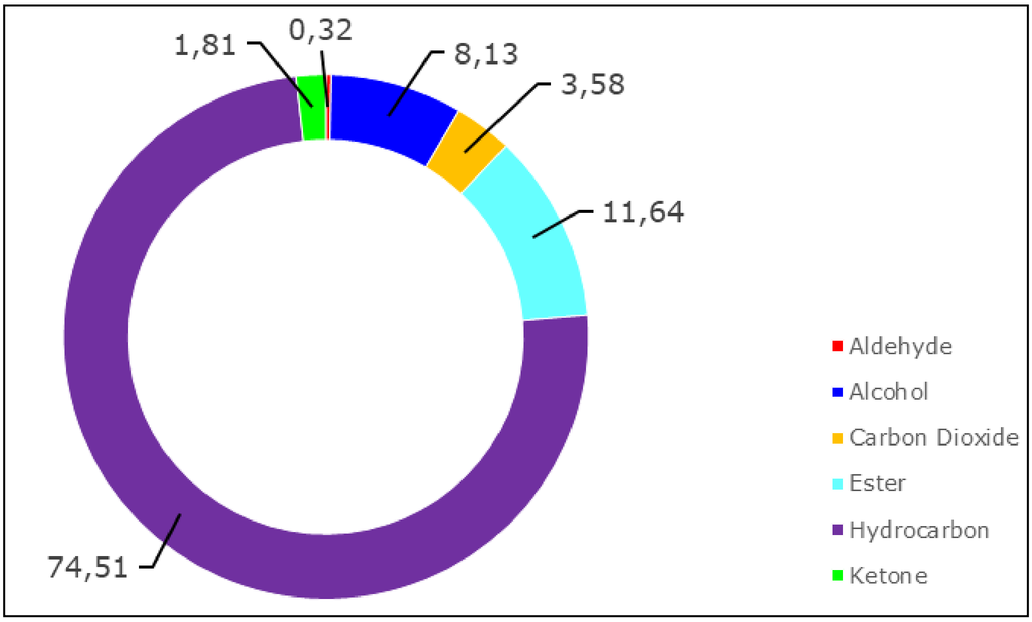

Figure 3. Total volatile compound groups of sediment from Jada Bahrin River.

Benzene accumulation has been observed in *Gafrarium divaricatum*, with concentration between 4.35 and 8.70 mg L^{-1}. Chronic exposure of clams to benzene resulted in loss of bubbling epithelium, separation and necrosis of epithelial cells, reduction in cytoplasm volume and density, fusion of cell membranes, disruption of the inner lining of tubules, and nuclei forming darkly stained areas at basal part of the cells (Agwuocha et al 2011). The presence of benzene in the environment at a concentration of 5.69 μL L^{-1} also affects the physiological processes of mussels, *Perna perna*, reducing oxygen consumption and ammonia excretion (Jorge et al 2007). Furthermore, aromatic hydrocarbon pollutants such as benzene, toluene, and xylene (BTX) contribute to damaging DNA in the bivalve *Corbicula fluminea* (Fedato et al 2010). In this research, we did not obtain benzene contaminated kepah meat in Jada Bahrin River. However, compounds that contain benzene were found in the sediment, so the potential contamination with benzene and its derivates should be considered in future studies.

Overall, this study showed that *P. erosa* can be used as a bioindicator of organic pollutants such as volatile organic compounds. VOCs found in the meat of kepah represented accumulated pollutants from the habitat (Nuryanto & Sastranegara 2013). In this study, we found VOCs containing benzene in the sediment, where benzene can be persistent (Jenneskens et al 2011). Furthermore, we must monitor the presence of benzene that accumulated in kepah. The potential of toxicity for human health is important, because it can produce carcinogenic effects, acute and chronic diseases, nervous system diseases, reproductive and developmental problems, immune system issues, respiratory problems, and hematological diseases (Falzone et al 2016; Dettenrieder et al 2020).

Conclusions. We have confirmed Pyr-GC/MS as an applicable instrument for determining volatile organic compounds (VOCs) in kepah meat, water and sediment. Hydrocarbons were the most abundant compound in kepah meat, water, and sediment, collected from Jada Bahrin River, Bangka Regency, Bangka Island, Indonesia.

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Conflict of Interest. The authors declare that there is no conflict of interest.

References

Agwuocha S., Kulkarni B. G., Pandey A. K., 2011 Histopathological alterations in hepatopancreas of *Gafrarium divaricatum* exposed to xylene, benzene and gear oil-WSF. Journal of Environmental Biology 32(1):35-38.

Argente F. A. T., 2016 Bivalve superpower: the global invasion of corbiculid clams. Annual Research & Review in Biology 10(3):1-10.

Batubara R., Hanum T. I., Affandi O, 2021 GC-MS analysis of young and mature wild agarwood leaves (*Aquilaria malaccensis* Lamk) and its antioxidant potential. IOP Conference Series: Earth and Environmental Science 912:012038.

Biona M. A., Marte C. R., Pasadilla A. L. G., Araneta, B. Y. G., 2017 Estimation of the edible wet tissue weight of the mangrove clam *Polymesoda erosa* harvested from the wild. PEERS Inc. Multidisciplinary Research Journal 1(1):1-9.

Bouzid N., Anquetil C., Dris R., Gasperi J., Tassin B., Derenne S., 2022 Quantification of microplastics by pyrolysis coupled with gas chromatography and mass spectrometry in sediments: Challenges and implications. Microplastics 1(2):229-239.

Bravo-Linares C. M., Mudge S. M., Loyola-Sepulveda R. H., 2010 Production of volatile organic compounds (VOCs) by temperate macroalgae: The use of Solid Phase Microextraction (SPME) coupled to GC-MS as method of analysis. Journal of the Chilean Chemical Society 55(2):227-232.

Cheng S., Zhang J., Wang Y., Zhang D., Teng G., Chang-Chien G. P., Qianli H., Zhang Y. B., Yan P., 2019 Global research trends in health effects of volatile organic compounds during the last 16 years: a bibliometric analysis. Aerosol and Air Quality Research 19(8):1834-1843.

Clemente S., Ingole B., 2011 Recruitment of mud clam *Polymesoda erosa* (Solander, 1876) in a mangrove habitat of Chorao Island, Goa. Brazilian Journal of Oceanography 59(2):153-162.

Conte S., Lagacé F., Netchiporouk E., Sasseville D., Litvinov I. V., 2021 Benzene, a known human carcinogen, detected in suncare products. Journal of Cutaneous Medicine and Surgery 25(6):650-651.

David E., Niculescu V. C., 2021 Volatile organic compounds (VOCs) as environmental pollutants: occurrence and mitigation using nanomaterials. International Journal of Environmental Research and Public Health 18(24):13147.

Dettenrieder C., Türkmen D., Mattsson A., Österlund L., Karlsson M., Mizaikoff B., 2020 Determination of volatile organic compounds in water by attenuated total reflection infrared spectroscopy and diamond-like carbon coated silicon wafers. Chemosensors 8(3):75.

Ding J., Sun C., He C., Li J., Ju P., Li F., 2021 Microplastics in four bivalve species and basis for using bivalves as bioindicators of microplastic pollution. Science of The Total Environment 782:146830.

Dini J. W., 2008 Volatile organic compounds in foods and beverages. Plating and Surface Finishing 95(5):14-15.

Falzone L., Marconi A., Loreto C., Franco S., Spandidos D. A., Libra M., 2016 Occupational exposure to carcinogens: Benzene, pesticides and fibers. Molecular Medicine Reports 14(5):4467-4474.

Fedato R. P., Simonato J. D., Martinez C. B. R., Sofia S. H., 2010 Genetic damage in the bivalve mollusk *Corbicula fluminea* induced by the water-soluble fraction of gasoline. Mutation Research/Genetic Toxicology and Environmental Mutagenesis 700(1-2):80-85.

Genovese A., Marrazzo A., De Luca L., Romano R., Manzo N., Masucci F., Di Francia A., Sacchi R., 2019 Volatile organic compound and fatty acid profile of milk from cows and buffaloes fed mycorrhizal or nonmycorrhizal ensiled forage. Molecules 24(8):1616.

Hadi Y. S., Nawawi D. S., Abdillah I. B., Pari G., Pari R., 2021 Evaluation of discoloration and subterranean termite resistance of four furfurylated tropical wood species after one-year outdoor exposure. Forests 12(7):900.

Hamli H., Rahim A. A., Idris M. H., Kamal A. H. M., King W. S., 2015 Morphometric variation among three local mangrove clam species of Corbiculidae. Songklanakarin Journal of Science and Technology 37(1):15-20.
Jenneskens L. W., Havenith R. W., Soncini A., Fowler P. W., 2011 Aromaticity of strongly bent benzene rings: persistence of a diatropic ring current and its shielding cone in [5] paracyclophane. Physical Chemistry Chemical Physics 13(37):16861-16866.
Jorge R. A. D. L. V. C., Lemos D., Moreira G. S., 2007 Effect of zinc and benzene on respiration and excretion of mussel larvae (*Perna perna*) (Linnaeus, 1758) (Mollusca; Bivalvia). Brazilian Journal of Biology 67(1):111-115.
Juang D. E., Yuan C. S., Hsueh S. C., Chiou L. J., 2009 Distribution of volatile organic compounds around a polluted river. International Journal of Environmental Science & Technology 6(1):91-104.
Latif M. T., Mei C. S., Hanif N. M., Srithawirat T., 2012 Levoglucosan as an indicator of biomass burning from selected tropical plants. EnvironmentAsia 5(2):22-27.
Leiwakabessy J., Nanlohy E. E., Lewerissa S., 2019 Fatty acid profile of some fresh and dried molluscs in Central Maluku, Indonesia. AACL Bioflux 12(4):1189-1195.
Meckenstock R. U., Boll M., Mouttaki H., Koelschbach J. S., Tarouco P. C., Weyrauch P., Dong X., Himmelberg A. M., 2016 Anaerobic degradation of benzene and polycyclic aromatic hydrocarbons. Microbial Physiology 26(1-3):92-118.
Mendoza D. M., Mula M. G., Baysa R. P., 2019 Spatial density, size, growth and condition index of mangrove clam (*Polymesoda erosa*) in the estuarine portion of Pasak River, Sasmuan, Pampanga, Philippines. International Journal of Fisheries and Aquatic Studies 7(4):258-262.
Montero-Montoya R., López-Vargas R., Arellano-Aguilar O., 2018 Volatile organic compounds in air: sources, distribution, exposure and associated illnesses in children. Annals of Global Health 84(2):225-238.
Mustapha S. H. B., 2020 [Microplastic contamination in mollusc Polymesoda]. Dissertation, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor, 64 p. [In Malay].
Mutić J., Jovanović V., Jacxsens L., Tondeleir J., Ristivojević P., Djurdjić S., Rajković A., Veličković T. Ć., 2021 Chemical content of five molluscan bivalve species collected from South Korea: multivariate study and safety evaluation. Foods 10(11):2690.
Nuryanto A., Sastranegara M. H., 2013 Molecular characterisation of *Polymesoda erosa* (Solander, 1786) inhabit two different habitats. Bionatura-Jurnal Ilmu-ilmu Hayati dan Fisik 15(3):184-189.
Patoni I., Susanto A., Hidayat Y., 2022. Potential of Fruit Extracts as Attractants of Female Oriental Fruit Flies. Pakistan Journal of Biological Sciences 25(6):537-548.
Peters C. A., Hendrickson E., Minor E. C., Schreiner K., Halbur J., Bratton S. P., 2018 Pyr-GC/MS analysis of microplastics extracted from the stomach content of benthivore fish from the Texas Gulf Coast. Marine Pollution Bulletin 137:91-95.
Smith M. T., 2010 Advances in understanding benzene health effects and susceptibility. Annual Review of Public Health 31:133-148.
Vinci R. M., Jacxsens L., De Meulenaer B., Deconink E., Matsiko E., Lachat C., de Schaetzen T., Canfyn M., Van Overmeire I., Kolsteren P., van Loco J., 2015 Occurrence of volatile organic compounds in foods from the Belgian market and dietary exposure assessment. Food Control 52:1-8.
Wang R., Mou H., Lin X., Zhu H., Li B., Wang J., Junaid M., Wang J., 2021 Microplastics in mollusks: research progress, current contamination status, analysis approaches, and future perspectives. Frontiers in Marine Science 1671(8):759919.
Wang Q., Wang C., Hou L., Lv B., Chén W. A. N. G., 2018 Pollution data analysis and characteristics of volatile organic compounds in the environment. E3S Web of Conferences 38:01004, 5 p.
Yadav R., Pandey P., 2018 A review on volatile organic compounds (VOCs) as environmental pollutants: fate and distribution. International Journal of Plant and Environment 4(2):14-26.
Yildizhan E., Koyutürk L. C., Akkuş M., Tektemur N. K., Özkorkmaz E. G., Fırat A. Ş. I. R., 2021 Examination of apoptotic changes in aromatic hydrocarbon benzene

administered rat testicular tissue with histopathological methods. Middle East Journal of Science 7(1):1-10.
Yusoff A. H., Roslan N. N., Chang C. S., Lazim A. M., Nadzir M. S. M., Oslan S. N. H., Sulaiman A. Z., Ahmed M. F., Mohamed M., Zakaria K. A., Tan R., 2021 Heavy metals in marsh clam (*Polymesoda expansa*) as bioindicators for pollution in industrial and sand mining area of Kelantan River Basin, Malaysia. Trends in Sciences 18(20):1-10.
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Profile of volatile organic compounds in kepah (*Polymesoda erosa* Solander, 1786) collected from Jada Bahrin River of Bangka Island, Indonesia

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Abstract. This study aimed to provide information about the profile of volatile organic compounds (VOCs) in kepah (*Polymesoda erosa* Solander, 1786), and also about sediment and water of their habitat in Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia. The analysis of VOCs was carried out using Pyrolysis-GC/MS analysis. A number of volatile organic compounds (VOCs) were measured, including aldehydes, alcohols, aromatic compounds, carbohydrates, carbon dioxide, esters, hydrocarbons, ketones, nitrogenous compounds, oxygen-sulfur compounds, and proteins. The hydrocarbons were the most abundant compound. Twenty-nine VOCs were detected in kepah meat with the highest concentration, namely Hexadecanoic acid (CAS) Palmitic acid (14.04%); Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor (19.41%), was the highest concentration of 28 VOCs that found in the water; and 1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene (6.36%) was the highest concentration of 60 VOCs that detected in sediment of Jada Bahrin River.

Key Words: volatile organic compounds, Pyrolysis-GC/MS, *Polymesoda erosa*, Jada Bahrin River.

Introduction. Volatile organic compounds (VOCs) are large groups of organic chemical compounds found in many products. They vaporize easily and enter the environment under normal conditions (Yadav & Pandey 2018). VOCs are defined by the US Environmental Protection Agency (U.S. EPA), as organic compounds with low initial boiling point (less than or equal to 250°C) at a standard atmospheric pressure of 101.3 kPa (Cheng et al 2019). Wang et al (2018) define VOCs as volatile organic compounds with higher saturated vapor pressure (greater than or equal to 0.01 kPa at 20°C), low boiling point, and small molecular weight. The VOCs are divided into non-methane hydrocarbons including alkanes, alkenes, alkynes and aromatic hydrocarbons (NMHCs), oxygen containing organic compounds including aldehydes, ketones, alcohols, ethers and halogenated hydrocarbons (OVOCs), nitrogenous compounds, sulfur compounds and other categories.

The VOCs are ubiquitous in the environment and they may represent health risks. The sources of VOCs are both natural and anthropogenic. Naturally, VOCs can be produced by macroalgae in response to environmental stresses and also from plants. VOCs generated by anthropogenic activities come from both domestic and industrial processes (Bravo-Linares et al 2010; David & Niculescu 2021). Since the industrial waste around the river could contain some hazardous VOCs that might affect the health of living organisms in the water and can enter the human body via food chain pathways. They can lead to symptoms and pathologies in the respiratory tract, nervous system, skin, kidneys and others. Some VOCs like benzene, 1,3-butadiene, and vinyl chloride are classified by the International Agency for Research on Cancer (IARC) in Group 1 as carcinogenic for humans (Juang et al 2009; Montero-Montoya et al 2018). On the other hand, VOCs in foods provide a flavor fingerprint that help humans recognize appropriate foods and avoid

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Commented [u5]: this is not a low boiling point; it is higher than water; please check and correct where necessary; maybe you mean 25°C poor or dangerous foods (Dini 2008). Most VOCs, such as ethyl esters, aldehydes, nitrogen compounds, ketones, alcohols, and dimethylsulphone, represent the main aromatic constituents of foods, and their quantitative differences can explain the different odors that characterize foods (Genovese et al 2019). Thus, it is important to understand their presence in the environment and especially in our diet and to identify possible sources of VOCs (Vinci et al 2015).

The mud or mangrove clam (*Polymesoda erosa* Solander, 1786), with the local name 'kepah' in Bangka Island, is an edible bivalve species. *P. erosa* can be found in intertidal areas, in mangrove substrate and in the fresh and brackish waters of mangrove swamps, estuaries, and larger rivers (Biona et al 2017). Molluscs have high economic value and reproduce easily. Furthermore, they have high nutritional value, and are considered a good source of proteins, lipids, and minerals. Molluscs are a highly regarded aquaculture resources, especially bivalves, which are typical filter feeders, constantly filtering out matter from the surrounding water (Wang et al 2021). *Polymesoda* sp. feed by filtering suspended particles in the water that surrounds them (Mustapha 2020). Bivalves are well known as filter feeders for suspended particles within water columns that may be contaminated with numerous pollutants from anthropogenic activities or natural factors (Yusoff et al 2021). Therefore, they could be a potential source of environmental organic and inorganic pollutants, which have a tendency to accumulate in their body and transferred to humans through consumption (Ding et al 2021; Mutić et al 2021).

This short communication aimed to provide information related to the volatile organic compounds from the meat of kepah, sediment and water collected from Jada Bahrin River, Bangka Regency, Bangka Island, Indonesia.

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Material and Method. This research took place from May to June 2022. The study was conducted by testing volatile organic compounds from samples (kepah, sediment, and water), collected from Jada Bahrin River, located in Bangka Regency, Bangka Island, Indonesia. We have sampled randomly 20 individuals of kepah, 1.5 L of water, and 100 g of sediment. The habitat of kepah in the area of sampling was represented by the mud around mangrove trees. The identification of kepah was done using as reference www.sealifebase.ca. Collected samples were stored in a cold box with at less than 5°C to prevent the decrease in VOC content. Kepah (0.0065 mg), sediment (0.0022 mg), and water of river (0.0077 mg) were used as samples in this study.

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The VOCs were determined using Pyrolysis Gas Chromatography–Mass Spectrometry (pyr-GC/MS) (Peters et al 2018; Bouzid et al 2022). Qualitative and quantitative analysis of volatile compounds was measured using the GCMS Pyrolysis Shimadzu GCMS-QP 2010, with a column length (rt x 5 ms) 60 m, 0.25 mm in diameter and 0.25 m thickness. The initial column oven temperature was held at 50°C for 5 min and increased by 2.5 °C min^{-1} to 150°C, and finally with 90°C min^{-1} to 280°C. In pyrolysis, it was set at 600°C. Gas Chromatography was set at a pressure of 101.0 kPa, total flow 46.5 mL min^{-1}, column flow 0.85 mL min^{-1}, with a linear velocity of 23.7 cm sec^{-1}. The ion source temperature and the interface temperature were maintained at 200 and 280°C, respectively, with a split ratio of 1:50 with 1 L of sample injected. The results of the GCMS-Pyrolysis test in the form of chromatograms were analyzed and tabulated using the Wiley 7 program.

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Results and Discussion. Argente (2016) explains that there are three genera within the Family Corbiculidae, which are distributed worldwide, namely *Batissa*, *Polymesoda*, and *Corbicula*. Hamli et al (2015) explain there are three common species of the genus *Polymesda* from the family Corbiculidae, class Bivalvia that can be found inhabiting the mangrove areas in Southeast Asia, namely *P. erosa*, *P. bengalensis*, and *P. expansa*. Kepah collected from Jada Bahrin River are presented in Figure 1.

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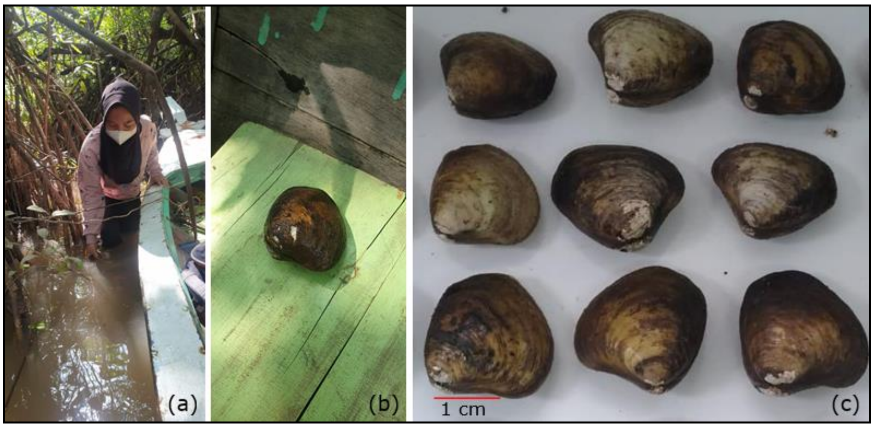

Figure 1. *Polymesoda erosa* from Jada Bahrin River of Bangka Regency, Indonesia; a - collection process; b - kepah after collection; c - kepah in the laboratory.

P. erosa is a non-seasonal species, resilient to contaminated environment, to both anorganic contaminants, such as heavy metals, and organic pollutants (Mendoza et al 2019). This clam can be used as a bioindicator of polluted habitats. It is a sessile organism, which might face adverse effects from environmental alteration due to pollutants. They are capable to accumulate pollutants in their tissue without dying and there is a positive correlation between pollutant concentration in the environment and in their body tissue (Nuryanto & Sastranegara 2013). Therefore, measures are needed to minimize the health risk for aquatic life, and for food sources for human consumption (Yusoff et al 2021).

Volatile organic compounds (VOCs) are a prime subject of research due to their toxicity and persistence in the environment (Chary & Fernandez-Alba 2012). They are one of the most commonly detected contaminants in water and have an impact on ecosystem, including on humans and animals, due to their toxicity, mutagenicity, and carcinogenicity (Dettenrieder et al 2020).

This study has identified some chemical compounds from kepah (*P. erosa*) and its habitat (sediment and water) from Jada Bahrin River of Bangka Island, Indonesia. Some VOCs were investigated and shown by chromatograms, while name and retention time (R. time) of total ion chromatography (TIC) based on peaks of chromatograms. Yadav & Pandey (2018) explain that VOCs include a variety of organic chemicals emitted as gases from certain solids and liquids. Wang et al (2018) and David & Niculescu (2021) note that the most common VOCs are the aromatic hydrocarbons such as benzene, toluene, xylene and ethyl benzene, non methane hydrocarbons including alkanes, alkenes, and alkynes, oxygen containing organic compounds including aldehydes, ketones, alcohols, ethers, halogenated hydrocarbons such as chloroethylene and trichloroethylene, nitrogenous compounds, and sulfur compounds.

Twenty-nine VOCs were detected in kepah meat with the highest concentration found at peak 23 with a retention time of 22.975 min for hexadecanoic acid (CAS) (palmitic acid - 14.04%) (Table 1 and Figure 2). In total, 29 VOCs were identified from kepah meat samples. Of these compounds, there were 1 aldehyde, 3 alcohols, 1 aromatic compound (furan), 1 ester, 14 fatty acids, 5 hydrocarbons, 2 ketones, 1 nitrogenous compound, and 1 oxygen-sulfur compound (Figure 3). The fatty acids were the most abundant compounds, including lauric acid, stearic acid, behenic acid, myristic acid, palmitic acid, margaric acid, oleic acid, and derivates such as hexadecanamide and nonadecanamide.

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Table 1
Volatile organic compounds of *Polymesoda erosa* meat from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	7.293	3.47	Nitrogen oxide (N_2O) (CAS) Nitrous oxide
2	7.717	1.76	1,4-oxathiane, 4,4-dioxide (CAS) p-Thioxane sulfone
3	16.138	0.43	2-cyclopenten-1-one, 2-hydroxy-3-methyl- (CAS) Corylon
4	16.723	0.49	Isooctane, (ethenyloxy)- (CAS) Isooctyl Vinyl Ether
5	17.017	0.72	Pentanal (CAS) n-Pentanal
6	17.392	0.40	1,3-pentanediol, 2,2,4-trimethyl- (CAS) 2,2,4-trimethyl-1,3-pentanediol
7	17.640	0.51	Decane, 2,3,5,8-Tetramethyl-
8	18.029	0.53	2-butene-1,4-diol, (Z)- (CAS) cis-Butenediol
9	18.480	0.35	Tetradecane (CAS) n-Tetradecane
10	18.992	0.65	2-undecene, 2,5-dimethyl- (CAS) 2,5-dimethyl-2-undecene
11	19.271	0.61	Pentadecane (CAS) n-Pentadecane
12	19.555	0.61	9-octadecenoic acid (Z)- (CAS) Oleic acid
13	19.767	0.45	Nonadecanol
14	20.017	0.83	Dodecane, 2,6,10-trimethyl- (CAS) Farnesane
15	20.218	1.56	Dodecanoic acid (CAS) Lauric acid
16	20.636	1.79	10-undecenoic acid, octyl ester (CAS) Octyl 10-undecenoate
17	20.892	2.24	Octadecanoic acid (CAS) Stearic acid
18	21.313	2.51	Docosanoic acid (CAS) Behenic acid
19	21.570	5.08	Tetradecanoic acid (CAS) Myristic acid
20	22.011	3.76	Pentadecanoic acid (CAS) Pentadecylic acid
21	22.226	5.34	Pentadecanoic acid (CAS) Pentadecylic acid
22	22.685	3.62	Hexadecanoic acid (CAS) Palmitic acid
23	22.975	14.04	Hexadecanoic acid (CAS) Palmitic acid
24	23.359	5.48	Heptadecanoic acid (CAS) Margaric acid
25	23.639	7.46	Heptadecanoic acid (CAS) Margaric acid
26	24.120	2.83	2(3H)-guranone, 5-dodecyldihydro- (CAS). gamma.-Palmitolactone
27	24.404	8.49	9-octadecenoic acid (Z)- (CAS) Oleic acid
28	24.795	6.29	Hexadecanamide (CAS) Amide 16
29	25.356	3.86	Nonadecanamide

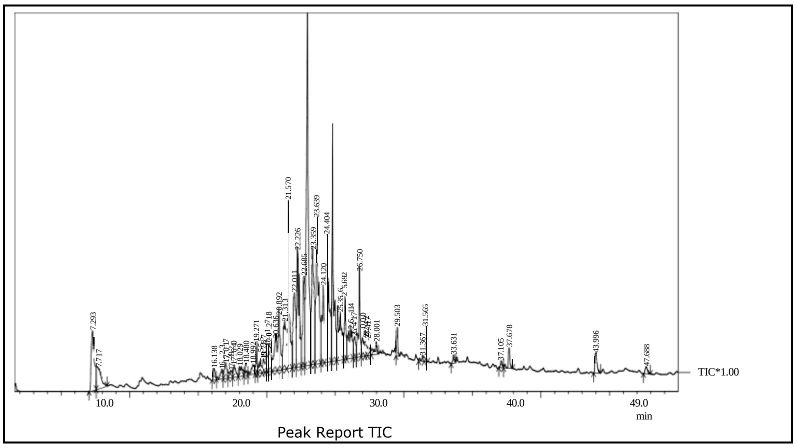

Figure 2. Total chromatogram of *Polymesoda erosa* meat from Jada Bahrin River of Bangka Regency.

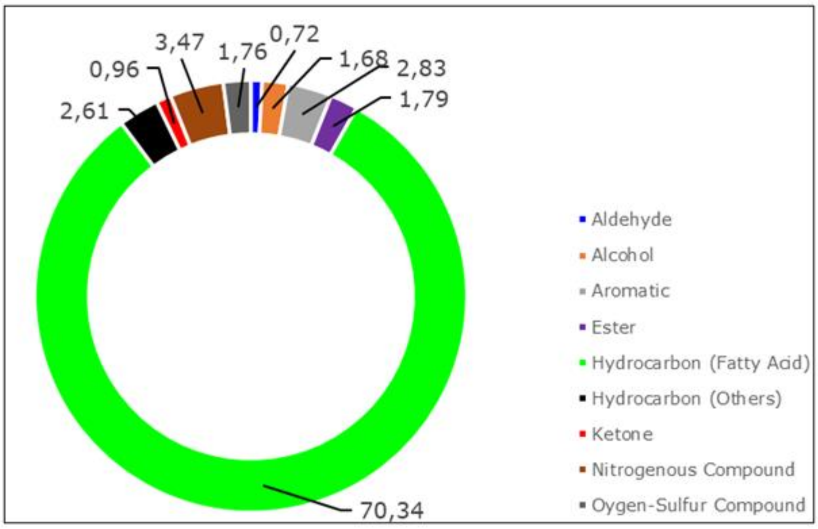

Figure 3. Total volatile compound groups of *Polymesoda erosa* meat.

P. erosa is a mollusc with a great nutritional potential, especially in fatty acids. Some of the saturated fatty acids (SFAs) from *P. erosa* are palmitic acid (C16:0), myristic acid (C14:0), lauric acid (C12:0), stearic acid (C18:0), behenic acid (C22:0), and pentadecanoic acid (C15:0). Monounsaturated fatty acids (MUFA) are margaric acid (17:1) and oleic acid (C18:1n9c), as found in this research, but also by Leiwakabessy et al (2019). Polyunsaturated fatty acids from *P. erosa* were not found in this study.

Fatty acids are common components of complex lipids. While, lipids play an important role in maintaining the integrity of animals, especially as structural compounds by forming a barrier separating the living cell from the outside, the major source of cellular energy and function in living organisms, structural and signaling roles in the cell (Horn, & Jaiswal 2019; Pal et al 2018). In addition, SFAs more lead to increase low-density lipoprotein (LDL) cholesterol levels and elevate plasma cholesterol levels as risk factors for cardiovascular disease (Gershuni 2018), coronary artery diseases, and rates of mortality from cardiovascular disease (Borges et al 2020). Whereas, consumption of MUFAs promote healthy blood lipid profiles, mediates blood pressure, improves insulin sensitivity, and regulates glucose levels (Gillingham et al 2011). Furthermore, PUFAs play a major role in the functions of the immune system and the maintenance all hormonal systems of the organism (Tran et al 2019). The omega-3-fatty acids and omega-6-fatty acids, two groups of PUFAs are considered as essential fatty acids because for human. They cannot be synthesized by humans, but they are essential nutrients for health and development such as decreasing the risk of myocardial infarction, lowering blood pressure and triglyceride concentration in blood, enhancing the immune system, sustaining proper brain function, protect against various psychological disorders, depression and attention deficit hyperactivity disorder in particular and cancer (Pal et al 2018).

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We also analyzed VOCs of water from Jada Bahrin River. There were 28 VOCs detected in the water, with the highest concentration found at peak 26 with a retention time of 20.762 min, for 1,6-anhydro-Beta-D-Glucopyranose (Levoglucosan) (24.88%) (Table 2 and Figure 4). Latif et al (2012) explain Levoglucosan (1,6-anhidro-β-D-glucopyranose) is an organic molecule that can be used as an indicator for cellulose burning. Thus, it is possible that Levoglucosan from filter paper has contaminated the pyrolysis of VOCs.

Of the identified compounds, there were 6 aldehydes, 5 alcohols, 2 carbohydrates, 1 ester, 9 hydrocarbons, 4 ketones, and 1 protein (Figure 5). The hydrocarbons were the most abundant compound in the water. Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor, was the highest VOC found in the water of Jada Bahrin River, after Levoglucan (which was presumed to have contaminated the sample). Cyclopropane belongs to the class of organic compounds known as cycloalkanes, a group of hydrocarbons, found at peak 1 with a retention time of 6.486 min and a concentration of 19.41%.

Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor is an organic compound found in jabon (*Anthocephalus cadamba*) (Hadi et al 2021) and has antioxidant properties in young agarwood (*Aquilaria malaccensis* Lamk) leaves (Batubara et al 2021). Thus, we did not consider this VOC as a dangerous compound for the environment or for human health.

Table 2

Volatile organic compounds of water from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	6.486	19.41	Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor
2	8.260	3.24	2-methyl-3-oxo-Butyronitrile
3	9.025	0.50	Pentane (CAS) n-Pentane
4	9.412	2.98	Acetic acid (CAS) Ethylic acid
5	9.796	6.17	2-propanone, 1-hydroxy- (CAS) Acetol
6	11.591	0.43	2,3-pentanedione (CAS) 2,3-pentadione
7	11.825	1.07	Propanoic acid, 2-oxo-, methyl ester (CAS) Methyl pyruvate
8	12.179	0.77	1-cyano-6-hydroxypentane
9	12.594	0.53	2-furancarboxaldehyde (CAS) Furfural
10	13.156	0.35	2-propanone, 1-(acetyloxy)- (CAS) Acetol acetate
11	13.325	1.63	2-furanmethanol (CAS) Furfuryl alcohol
12	14.351	1.99	Cyclohexanone (CAS) Anon
13	14.525	1.47	2-furancarboxaldehyde, 5-methyl- (CAS) 5-methyl-2-furfural
14	15.562	1.91	2-cyclopenten-1-one, 2-hydroxy-3-methyl- (CAS) Corylon
15	15.988	1.71	Hydroxy Dimethyl Furanone
16	16.379	5.90	Pentanal (CAS) n-Pentanal
17	16.967	1.82	7-methyl-1,4-dioxaspiro[2.4]heptan-5-one
18	17.196	1.69	1-octene (CAS) Caprylene
19	17.561	2.62	Oxirane, 2-butyl-3-methyl- (CAS) 2,3-epoxyheptane
20	18.046	4.42	2-furancarboxaldehyde, 5-(hydroxymethyl)- (CAS) HMF
21	18.442	1.15	4-heptanol, 2,6-dimethyl-4-(1-methylethyl)- (CAS) 2,6-dimethyl-4-Isopro
22	18.912	3.11	Ethenol, 2-ethoxy-, acetate (CAS)
23	19.392	1.66	L-Glutamic acid, N-[(phenylmethoxy)carbonyl]-
24	19.667	2.52	2-propenoic acid, 2-methyl-, hexyl ester (CAS) Hexyl methacrylate
25	20.075	1.27	1-cyclohexene-1-carboxylic acid (CAS) 1-cyclohexenecarboxylic acid
26	20.762	24.88	1,6-anhydro-Beta-D-Glucopyranose (Levoglucosan)
27	21.775	2.44	1,6-anhydro-Beta-D-Glucofuranose
28	22.308	2.36	4-decenoic acid, methyl ester (CAS) Methyl dec-4-enoate

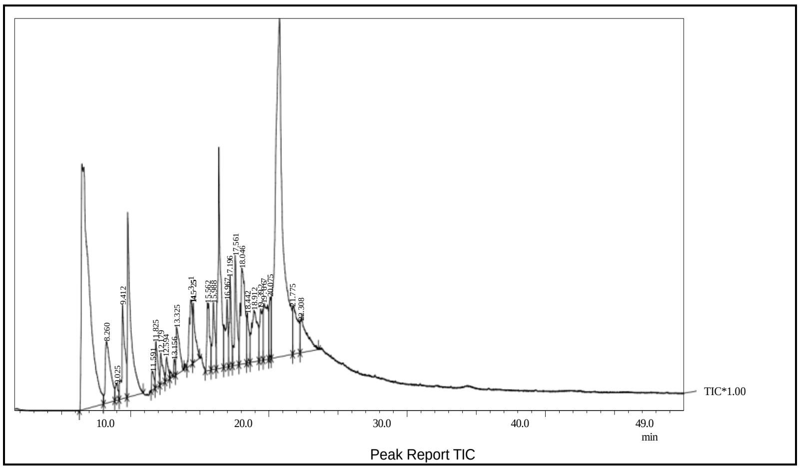

Figure 4. Total chromatogram of water from Jada Bahrin River of Bangka Regency.

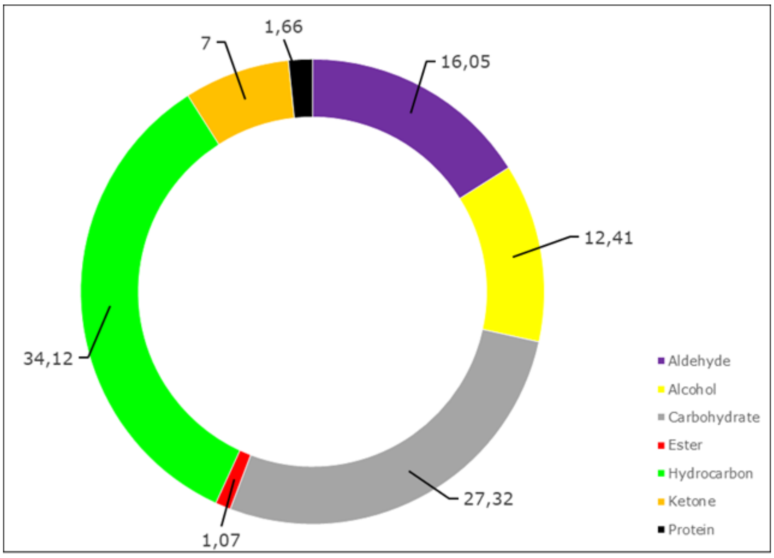

Figure 5. Total volatile compound groups in the water of Jada Bahrin River.

Sixty VOCs were detected in the sediment of Jada Bahrin River, with the highest concentration found at peak 50, with a retention time 41.694 min, for 1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene (6.36%) (Table 3 and Figure 6). Of the identified compounds, there were 1 aldehyde, 4 alcohols, 1 carbon dioxide, 6 esters, 45 hydrocarbons, and 3 ketones (Figure 7). The hydrocarbons were the most abundant compound type in the sediment. We found two VOC hydrocarbons that contain benzene, namely Benzofuran, 2,3-dihydro- (CAS) 2,3-Dihydrobenzofuran (R. Time 18.481 min, 1.48%) and 1H-Benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-, (R. Time 36.717 min, 0.58%).

Benzene is an aromatic hydrocarbon and a colorless and odorous liquid (Meckenstock et al 2016; Yildizhan et al 2021). It is formed from both natural processes and human activities. It is classified as carcinogen for humans, with effects such as acute leukemia and probably other hematological cancers. It is the primary starting material for chemicals used to make plastics, resins, synthetic fibers, nylons, dyes, detergents, drugs, pesticides, and also a component of crude oil (Smith 2010; Conte et al 2021). In the environment, this pollutant can be accumulated in organisms through direct or indirect routes. It is potentially accumulated in filter feeder organisms such as a clams.

Table 3

Volatile organic compounds of sediment from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	7.243	3.58	Carbon dioxide (CAS) Dry ice
2	17.642	0.53	10-undecenoic acid, Octyl ester (CAS) Octyl 10-Undecenoate
3	18.242	0.56	Nonanoic acid (CAS) Nonoic acid
4	18.481	1.48	Benzofuran, 2,3-dihydro- (CAS) 2,3-Dihydrobenzofuran
5	18.992	0.66	Decanoic acid (CAS) Capric acid
6	19.268	0.70	1-Octanol, 2-butyl- (CAS) 2-Butyl-1-octanol
7	19.492	0.32	2-Butanone, 4-cyclohexyl- (CAS) 4-Cyclohexyl-2-butanone
8	19.817	0.75	(1R*,6S*,10R*)-5,5-dimethyl-11,12-dioxatricyclo[8.2.1.0(1,6)]tridecan-10-ol
9	20.009	0.66	Hexadecane (CAS) n-Hexadecane
10	20.337	1.04	Docosanoic acid (CAS) Behenic acid
11	20.713	0.87	Tricosane (CAS) n-Tricosane
12	20.941	1.28	3-Hexadecene, (Z)- (CAS)
13	21.541	2.79	9-octadecenoic acid (Z)- (CAS) Oleic acid
14	21.867	0.47	2-undecanone, 6,10-dimethyl- (CAS) 6,10-dimethylundecan-2-one
15	22.067	2.35	Tetratetracontane (CAS) n-Tetratetracontane
16	23.015	4.98	Oxacycloheptadec-8-en-2-one (CAS) Ambrettolide
17	23.446	0.88	Pentatriacontane (CAS) n-Pentatriacontane
18	23.667	0.59	Megastigma-3,7(Z),9-triene
19	24.197	1.34	Pentatriacontane (CAS) n-Pentatriacontane
20	24.621	1.55	Oxacycloheptadec-8-en-2-one (CAS) Ambrettolide
21	25.026	1.16	Octadecane, 1-chloro- (CAS) 1-chlorooctadecane
22	25.974	0.40	Pentatriacontane (CAS) n-Pentatriacontane
23	26.891	0.69	Cyclododecanone (CAS) Cyclododecanon
24	27.067	0.37	Hexatriacontane (CAS) n-Hexatriacontane
25	27.973	0.60	1,2-Propanediol, 3-(Phenylmethoxy)-, Diacetate
26	28.388	0.52	Pentatriacontane (CAS) n-Pentatriacontane
27	29.667	1.22	Tetrapentacontane, 1,54-dibromo-
28	29.966	1.79	Tetratetracontane (CAS) n-Tetratetracontane
29	31.909	1.39	Pentatriacontane (CAS) n-Pentatriacontane
30	32.567	1.98	1-Hentetracontanol (CAS) N-Hentetracontanol-1
31	32.790	0.82	6-O-acetyl-7-desoxy-1,2:3,4:8,9:11,12-tetra-O-isopropyliden-7-nitro-.beta.-D-
32	33.117	1.05	Methyl Commate E
33	33.688	3.97	Nonacosanol (CAS)
34	34.060	1.81	Hexacosane, 9-octyl- (CAS) 9-n-Octylhexacosane
35	34.303	1.11	Pentatriacontane (CAS) n-Pentatriacontane
36	34.920	2.67	9,19-Cyclolanost-24-en-3-ol, Acetate
37	35.438	0.65	2-Pentadecanone, 6,10,14-trimethyl- (CAS) 6,10,14-Trimethyl-2-pentadecano
38	36.269	5.36	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy)trimethyl- (CAS) Cycl
39	36.717	0.58	1H-Benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-,

Peak	Retention time (min)	Concentration (%)	Name
40	36.999	3.43	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy)trimethyl- (CAS) Cycl
41	37.474	1.18	Cycloeucalenol
42	37.817	1.48	Nonacosanol (CAS)
43	38.368	0.70	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy) trimethyl- (CAS) Cycl
44	38.590	0.79	Androst-5-en-3-ol, 4,4-dimethyl-, (3.beta.)- (CAS)
45	39.044	1.50	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
46	39.550	1.20	Cycloeucalenol
47	40.053	1.78	Androst-5-en-3-ol, Trifluoroacetate, (3.beta.)- (CAS)
48	40.639	2.68	13,27-Cycloursan-3-ol, Acetate, (3.Beta.,13.Beta.,14.Beta.)-
49	40.942	0.97	Tetracosane, 11-decyl- (CAS) 11-n-Decyltetracosane
50	41.694	6.36	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
51	42.132	3.08	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
52	42.629	3.31	4,4,6A,6B,8A,11,11,14B-octamethyl-1,4,4A,5,6,6A,6B,7,8,8A,9,10,11,12,
53	43.051	1.01	Norolean-12-ene
54	43.841	0.67	4,4,6A,6B,8A,11,11,14B-octamethyl-1,4,4A,5,6,6A,6B,7,8,8A,9,10,11,12,
55	44.417	0.57	9,19-cyclolanost-24-en-3-ol, Acetate
56	44.867	5.70	9,19-cyclolanost-24-en-3-ol, (3.beta.)- (CAS) Cycloartenol
57	45.517	0.68	Pentatriacontane (CAS) n-Pentatriacontane
58	45.828	2.30	6-isopropenyl-4,8A-dimethyl-3,5,6,7,8,8A-Hexahydro-1H-Naphth
59	46.399	1.22	9,19-cyclolanost-24-en-3-ol, (3.beta.)- (CAS) Cycloartenol
60	47.407	3.86	14-.Beta.-H-Pregna

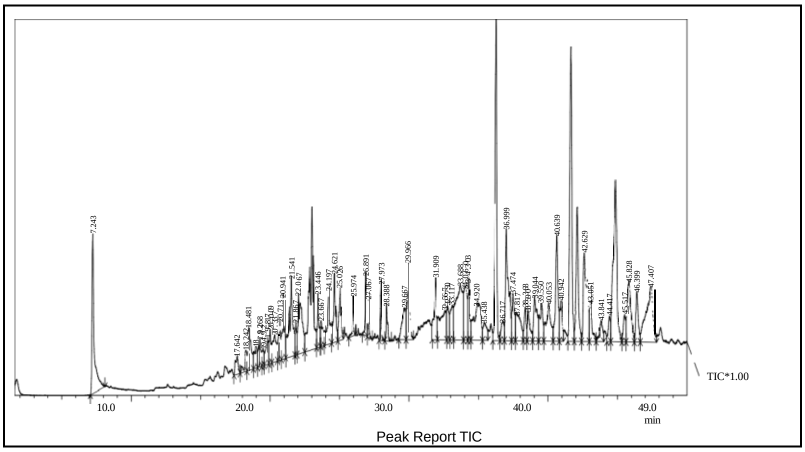

Figure 6. Total chromatogram of sediment from Jada Bahrin River of Bangka Regency.

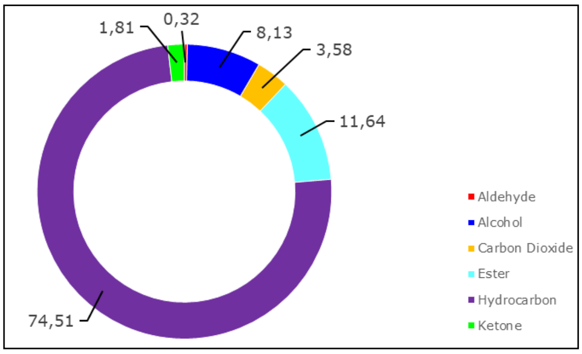

Figure 3. Total volatile compound groups of sediment from Jada Bahrin River.

Benzene accumulation has been observed in *Gafrarium divaricatum*, with concentration between 4.35 and 8.70 mg L^{-1}. Chronic exposure of clams to pollutants resulted in loss of bubbling epithelium, separation and necrosis of epithelial cells, reduction in cytoplasm volume and density, fusion of cell membranes, disruption of the inner lining of tubules, and nuclei forming darkly stained areas at basal part of the cells (Agwuocha et al 2011). The presence of toxic agents in the environment at a concentration of 5.69 µL L^{-1} also affects the physiological processes of mussels, *Perna perna*, reducing oxygen consumption and ammonia excretion (Jorge et al 2007). Furthermore, aromatic hydrocarbon pollutants such as benzene, toluene, and xylene (BTX) contribute to damaging DNA in the bivalve *Corbicula fluminea* (Fedato et al 2010). In this research, we did not obtain benzene contaminated kepah meat in Jada Bahrin River. However, compounds that contain benzene were found in the sediment, so the potential contamination with benzene and its derivates should be considered in future studies.

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Conclusions. We have confirmed Pyr-GC/MS as an applicable instrument for determining volatile organic compounds (VOCs) in kepah meat, water and sediment. Hydrocarbons were the most abundant compound in kepah meat, water, and sediment, collected from Jada Bahrin River, Bangka Regency, Bangka Island, Indonesia.

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Conflict of Interest. The authors declare that there is no conflict of interest.

References

Agwuocha S., Kulkarni B. G., Pandey A. K., 2011 Histopathological alterations in hepatopancreas of *Gafrarium divaricatum* exposed to xylene, benzene and gear oil-WSF. Journal of Environmental Biology 32(1):35-38.

Argente F. A. T., 2016 Bivalve superpower: the global invasion of corbiculid clams. Annual Research & Review in Biology 10(3):1-10.

Batubara R., Hanum T. I., Affandi O, 2021 GC-MS analysis of young and mature wild agarwood leaves (*Aquilaria malaccensis* Lamk) and its antioxidant potential. IOP Conference Series: Earth and Environmental Science 912:012038.

Biona M. A., Marte C. R., Pasadilla A. L. G., Araneta, B. Y. G., 2017 Estimation of the edible wet tissue weight of the mangrove clam *Polymesoda erosa* harvested from the wild. PEERS Inc. Multidisciplinary Research Journal 1(1):1-9.

Borges M. C., Schmidt A. F., Jefferis B., Wannamethee S. G., Lawlor D. A., Kivimaki M., Kumari M., Gaunt T. R., Ben-Shlomo Y., Tillin T., Menon U., Providencia R., Dale C., Gentry-Maharaj A., Hughes A, Chaturvedi N., Casas J. P., Hingorani A. D., UCLEB

Consortium., 2020 Circulating fatty acids and risk of coronary heart disease and stroke: individual participant data meta-analysis in up to 16 126 participants. Journal of the American Heart Association 9(5): e013131.
Bouzid N., Anquetil C., Dris R., Gasperi J., Tassin B., Derenne S., 2022 Quantification of microplastics by pyrolysis coupled with gas chromatography and mass spectrometry in sediments: Challenges and implications. Microplastics 1(2):229-239.
Bravo-Linares C. M., Mudge S. M., Loyola-Sepulveda R. H., 2010 Production of volatile organic compounds (VOCs) by temperate macroalgae: The use of Solid Phase Microextraction (SPME) coupled to GC-MS as method of analysis. Journal of the Chilean Chemical Society 55(2):227-232.
Chary N. S., Fernandez-Alba A. R., 2012 Determination of volatile organic compounds in drinking and environmental waters. TrAC Trends in Analytical Chemistry 32:60-75.
Cheng S., Zhang J., Wang Y., Zhang D., Teng G., Chang-Chien G. P., Qianli H., Zhang Y. B., Yan P., 2019 Global research trends in health effects of volatile organic compounds during the last 16 years: a bibliometric analysis. Aerosol and Air Quality Research 19(8):1834-1843.
Clemente S., Ingole B., 2011 Recruitment of mud clam *Polymesoda erosa* (Solander, 1876) in a mangrove habitat of Chorao Island, Goa. Brazilian Journal of Oceanography 59(2):153-162.
Conte S., Lagacé F., Netchiporouk E., Sasseville D., Litvinov I. V., 2021 Benzene, a known human carcinogen, detected in suncare products. Journal of Cutaneous Medicine and Surgery 25(6):650-651.
David E., Niculescu V. C., 2021 Volatile organic compounds (VOCs) as environmental pollutants: occurrence and mitigation using nanomaterials. International Journal of Environmental Research and Public Health 18(24):13147.
Dettenrieder C., Türkmen D., Mattsson A., Österlund L., Karlsson M., Mizaikoff B., 2020 Determination of volatile organic compounds in water by attenuated total reflection infrared spectroscopy and diamond-like carbon coated silicon wafers. Chemosensors 8(3):75.
Ding J., Sun C., He C., Li J., Ju P., Li F., 2021 Microplastics in four bivalve species and basis for using bivalves as bioindicators of microplastic pollution. Science of The Total Environment 782:146830.
Dini J. W., 2008 Volatile organic compounds in foods and beverages. Plating and Surface Finishing 95(5):14-15.
Fedato R. P., Simonato J. D., Martinez C. B. R., Sofia S. H., 2010 Genetic damage in the bivalve mollusk *Corbicula fluminea* induced by the water-soluble fraction of gasoline. Mutation Research/Genetic Toxicology and Environmental Mutagenesis 700(1-2):80-85.
Genovese A., Marrazzo A., De Luca L., Romano R., Manzo N., Masucci F., Di Francia A., Sacchi R., 2019 Volatile organic compound and fatty acid profile of milk from cows and buffaloes fed mycorrhizal or nonmycorrhizal ensiled forage. Molecules 24(8):1616.
Gershuni V. M., 2018 Saturated fat: part of a healthy diet. Current Nutrition Reports 7(3): 85-96.
Gillingham L. G., Harris-Janz S., Jones P. J. 2011 Dietary monounsaturated fatty acids are protective against metabolic syndrome and cardiovascular disease risk factors. Lipids 46(3): 209-228.
Hadi Y. S., Nawawi D. S., Abdillah I. B., Pari G., Pari R., 2021 Evaluation of discoloration and subterranean termite resistance of four furfurylated tropical wood species after one-year outdoor exposure. Forests 12(7):900.
Hamli H., Rahim A. A., Idris M. H., Kamal A. H. M., King W. S., 2015 Morphometric variation among three local mangrove clam species of Corbiculidae. Songklanakarin Journal of Science and Technology 37(1):15-20.
Horn A., Jaiswal J. K. 2019, Structural and signaling role of lipids in plasma membrane repair. Current Topics in Membranes 84: 67-98.

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Jorge R. A. D. L. V. C., Lemos D., Moreira G. S., 2007 Effect of zinc and benzene on respiration and excretion of mussel larvae (*Perna perna*) (Linnaeus, 1758) (Mollusca; Bivalvia). Brazilian Journal of Biology 67(1):111-115.
Juang D. E., Yuan C. S., Hsueh S. C., Chiou L. J., 2009 Distribution of volatile organic compounds around a polluted river. International Journal of Environmental Science & Technology 6(1):91-104.
Latif M. T., Mei C. S., Hanif N. M., Srithawirat T., 2012 Levoglucosan as an indicator of biomass burning from selected tropical plants. EnvironmentAsia 5(2):22-27.
Leiwakabessy J., Nanlohy E. E., Lewerissa S., 2019 Fatty acid profile of some fresh and dried molluscs in Central Maluku, Indonesia. AACL Bioflux 12(4):1189-1195.
Meckenstock R. U., Boll M., Mouttaki H., Koelschbach J. S., Tarouco P. C., Weyrauch P., Dong X., Himmelberg A. M., 2016 Anaerobic degradation of benzene and polycyclic aromatic hydrocarbons. Microbial Physiology 26(1-3):92-118.
Mendoza D. M., Mula M. G., Baysa R. P., 2019 Spatial density, size, growth and condition index of mangrove clam (*Polymesoda erosa*) in the estuarine portion of Pasak River, Sasmuan, Pampanga, Philippines. International Journal of Fisheries and Aquatic Studies 7(4):258-262.
Montero-Montoya R., López-Vargas R., Arellano-Aguilar O., 2018 Volatile organic compounds in air: sources, distribution, exposure and associated illnesses in children. Annals of Global Health 84(2):225-238.
Mustapha S. H. B., 2020 [Microplastic contamination in mollusc Polymesoda]. Dissertation, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor, 64 p. [In Malay].
Mutić J., Jovanović V., Jacxsens L., Tondeleir J., Ristivojević P., Djurdjić S., Rajković A., Veličković T. Ć., 2021 Chemical content of five molluscan bivalve species collected from South Korea: multivariate study and safety evaluation. Foods 10(11):2690.
Nuryanto A., Sastranegara M. H., 2013 Molecular characterisation of *Polymesoda erosa* (Solander, 1786) inhabit two different habitats. Bionatura-Jurnal Ilmu-ilmu Hayati dan Fisik 15(3):184-189.
Pal J., Shukla B. N., Maurya A. K., Verma H. O., Pandey G., Amitha A., 2018 A review on role of fish in human nutrition with special emphasis to essential fatty acid. International Journal of Fisheries and Aquatic Studies 6(2): 427-430.
Peters C. A., Hendrickson E., Minor E. C., Schreiner K., Halbur J., Bratton S. P., 2018 Pyr-GC/MS analysis of microplastics extracted from the stomach content of benthivore fish from the Texas Gulf Coast. Marine Pollution Bulletin 137:91-95.
Smith M. T., 2010 Advances in understanding benzene health effects and susceptibility. Annual Review of Public Health 31:133-148.
Tran Q. T., Le T. T. T., Pham M. Q., Do T. L., Vu M. H., Nguyen D. C., Bach L. G., Bui L. M., Pham Q. L., 2019 Fatty acid, lipid classes and phospholipid molecular species composition of the marine clam *Meretrix lyrata* (Sowerby 1851) from Cua Lo Beach, Nghe An Province, Vietnam. Molecules 24(5):895.
Vinci R. M., Jacxsens L., De Meulenaer B., Deconink E., Matsiko E., Lachat C., de Schaetzen T., Canfyn M., Van Overmeire I., Kolsteren P., van Loco J., 2015 Occurrence of volatile organic compounds in foods from the Belgian market and dietary exposure assessment. Food Control 52:1-8.
Wang R., Mou H., Lin X., Zhu H., Li B., Wang J., Junaid M., Wang J., 2021 Microplastics in mollusks: research progress, current contamination status, analysis approaches, and future perspectives. Frontiers in Marine Science 1671(8):759919.
Wang Q., Wang C., Hou L., Lv B., Chén W. A. N. G., 2018 Pollution data analysis and characteristics of volatile organic compounds in the environment. E3S Web of Conferences 38:01004, 5 p.
Yadav R., Pandey P., 2018 A review on volatile organic compounds (VOCs) as environmental pollutants: fate and distribution. International Journal of Plant and Environment 4(2):14-26.
Yildizhan E., Koyutürk L. C., Akkuş M., Tektemur N. K., Özkorkmaz E. G., Fırat A. Ş. I. R., 2021 Examination of apoptotic changes in aromatic hydrocarbon benzene

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administered rat testicular tissue with histopathological methods. Middle East Journal of Science 7(1):1-10.
Yusoff A. H., Roslan N. N., Chang C. S., Lazim A. M., Nadzir M. S. M., Oslan S. N. H., Sulaiman A. Z., Ahmed M. F., Mohamed M., Zakaria K. A., Tan R., 2021 Heavy metals in marsh clam (*Polymesoda expansa*) as bioindicators for pollution in industrial and sand mining area of Kelantan River Basin, Malaysia. Trends in Sciences 18(20):1-10.
*** www.sealifebase.ca

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Profile of volatile organic compounds in kepah (*Polymesoda erosa* Solander, 1786) collected from Jada Bahrin River of Bangka Island, Indonesia

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Abstract. This study aimed to provide information about the profile of volatile organic compounds (VOCs) in kepah (*Polymesoda erosa* Solander, 1786), and also about sediment and water of their habitat in Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia. The analysis of VOCs was carried out using Pyrolysis-GC/MS analysis. A number of volatile organic compounds (VOCs) were measured, including aldehydes, alcohols, aromatic compounds, carbohydrates, carbon dioxide, esters, hydrocarbons, ketones, nitrogenous compounds, oxygen-sulfur compounds, and proteins. We have found that 29 VOCs were detected in kepah meat with the highest concentration, namely Hexadecanoic acid (CAS) Palmitic acid (14.04%). We also found 28 VOCs in the water with the highest concentration, namely Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor (19.41%). Furthermore, there were 60 VOCs that detected in sediment with the highest conventration, namely 1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene (6.36%).

Key Words: Degradation, Organic Chemical, Pyrolysis-GC/MS, Clam.

Introduction. Volatile organic compounds (VOCs) are large groups of organic chemical compounds found in many products. They vaporize easily and enter the environment under normal conditions (Yadav & Pandey 2018). VOCs are defined by the US Environmental Protection Agency (U.S. EPA), as organic compounds with low initial boiling point (less than or equal to 250°C) at a standard atmospheric pressure of 101.3 kPa (Cheng et al 2019). Wang et al (2018) define VOCs as volatile organic compounds with higher saturated vapor pressure (greater than or equal to 0.01 kPa at 20°C), low boiling point, and small molecular weight. The VOCs are divided into non-methane hydrocarbons including alkanes, alkenes, alkynes and aromatic hydrocarbons (NMHCs), oxygen containing organic compounds including aldehydes, ketones, alcohols, ethers and halogenated hydrocarbons (OVOCs), nitrogenous compounds, sulfur compounds and other categories.

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The VOCs are ubiquitous in the environment and they may represent health risks. The sources of VOCs are both natural and anthropogenic. Naturally, VOCs can be produced by macroalgae in response to environmental stresses and also from plants. VOCs generated by anthropogenic activities come from both domestic and industrial processes (Bravo-Linares et al 2010; David & Niculescu 2021). Since the industrial waste around the river could contain some hazardous VOCs that might affect the health of living organisms in the water and can enter the human body via food chain pathways. They can lead to symptoms and pathologies in the respiratory tract, nervous system, skin, kidneys and others. Some VOCs like benzene, 1,3-butadiene, and vinyl chloride are classified by the International Agency for Research on Cancer (IARC) in Group 1 as carcinogenic for humans (Juang et al 2009; Montero-Montoya et al 2018). On the other hand, VOCs in foods provide a flavor fingerprint that help humans recognize appropriate foods and avoid poor or dangerous foods (Dini 2008). Most VOCs, such as ethyl esters, aldehydes, nitrogen compounds, ketones, alcohols, and dimethylsulphone, represent the main aromatic constituents of foods, and their quantitative differences can explain the different odors that characterize foods (Genovese et al 2019). Thus, it is important to understand their presence in the environment and especially in our diet and to identify possible sources of VOCs (Vinci et al 2015).

Argente (2016) explains that there are three genera within the Family Corbiculidae, which are distributed worldwide, namely *Batissa*, *Polymesoda*, and *Corbicula*. Hamli et al (2015) explain there are three common species of the genus *Polymesda* from the family Corbiculidae, class Bivalvia that can be found inhabiting the mangrove areas in Southeast Asia, namely *P. erosa*, *P. bengalensis*, and *P. expansa*. The mud or mangrove clam (*Polymesoda erosa* Solander, 1786), with the local name 'kepah' in Bangka Island, is an edible bivalve species. *P. erosa* can be found in intertidal areas, in mangrove substrate and in the fresh and brackish waters of mangrove swamps, estuaries, and larger rivers (Biona et al 2017). Molluscs have high economic value and reproduce easily. Furthermore, they have high nutritional value, and are considered a good source of proteins, lipids, and minerals. Molluscs are a highly regarded aquaculture resources, especially bivalves, which are typical filter feeders, constantly filtering out matter from the surrounding water (Wang et al 2021). *Polymesoda* sp. feed by filtering suspended particles in the water that surrounds them (Mustapha 2020). Bivalves are well known as filter feeders for suspended particles within water columns that may be contaminated with numerous pollutants from anthropogenic activities or natural factors (Yusoff et al 2021). Therefore, they could be a potential source of environmental organic and inorganic pollutants, which have a tendency to accumulate in their body and transferred to humans through consumption (Ding et al 2021; Mutić et al 2021).

This study aimed to provide information related to the volatile organic compounds from the meat of kepah, sediment and water collected from Jada Bahrin River, Bangka Regency, Bangka Island, Indonesia.

Material and Method. This research took place from May to June 2022. The study was conducted by testing volatile organic compounds from samples (kepah, sediment, and water), collected from Jada Bahrin River, located in Bangka Regency, Bangka Island, Indonesia. We have sampled randomly 20 individuals of kepah, 1.5 L of water, and 100 g of sediment. The habitat of kepah in the area of sampling was represented by the mud around mangrove trees. The identification of kepah was done using as reference www.sealifebase.ca. Collected samples were stored in a cold box with at less than 5^{o}C to prevent the decrease in VOC content. Kepah (0.05 mg), sediment (0.05 mg), and water of river (0.05 mg) were used as samples in this study.

The VOCs were determined using Pyrolysis Gas Chromatography–Mass Spectrometry (pyr-GC/MS) (Peters et al 2018; Bouzid et al 2022). Qualitative and quantitative analysis of volatile compounds was measured using the GCMS Pyrolysis Shimadzu GCMS-QP 2010, with a column length (rt x 5 ms) 60 m, 0.25 mm in diameter and 0.25 m thickness. The initial column oven temperature was held at 50°C for 5 min and increased by 2.5 °C min^{-1} to 150°C, and finally with 90°C min^{-1} to 280°C. In pyrolysis, it was set at 600°C. Gas Chromatography was set at a pressure of 101.0 kPa, total flow 46.5 mL min^{-1}, column flow 0.85 mL min^{-1}, with a linear velocity of 23.7 cm sec^{-1}. The ion source temperature and the interface temperature were maintained at 200 and 280°C, respectively, with a split ratio of 1:50 with 1 mL of sample injected. Some VOCs were investigated and shown by chromatograms, while name and retention time (R. time) of total ion chromatography (TIC) based on peaks of chromatograms. The results of the GCMS-Pyrolysis test in the form of chromatograms were analyzed and tabulated using the Wiley 7 program.

Results and Discussion. Kepah collected from Jada Bahrin River are presented in Figure 1. We have found twenty-nine VOCs were detected in kepah meat with the highest concentration found at peak 23 with a retention time of 22.975 min for hexadecanoic acid (CAS) (palmitic acid - 14.04%) (Table 1 and Figure 2).

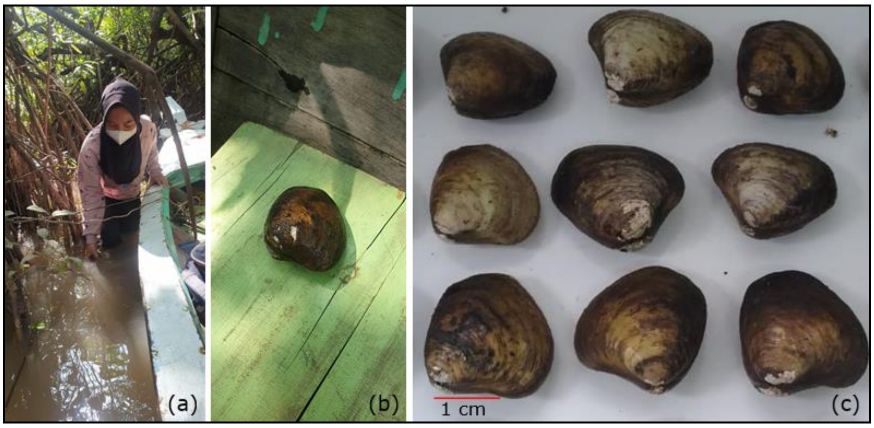

Figure 1. *Polymesoda erosa* from Jada Bahrin River of Bangka Regency, Indonesia; a - collection process; b - kepah after collection; c - kepah in the laboratory.

Table 1
Volatile organic compounds of *Polymesoda erosa* meat from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	7.293	3.47	Nitrogen oxide (N_2O) (CAS) Nitrous oxide
2	7.717	1.76	1,4-oxathiane, 4,4-dioxide (CAS) p-Thioxane sulfone
3	16.138	0.43	2-cyclopenten-1-one, 2-hydroxy-3-methyl- (CAS) Corylon
4	16.723	0.49	Isooctane, (ethenyloxy)- (CAS) Isooctyl Vinyl Ether
5	17.017	0.72	Pentanal (CAS) n-Pentanal
6	17.392	0.40	1,3-pentanediol, 2,2,4-trimethyl- (CAS) 2,2,4-trimethyl-1,3-pentanediol
7	17.640	0.51	Decane, 2,3,5,8-Tetramethyl-
8	18.029	0.53	2-butene-1,4-diol, (Z)- (CAS) cis-Butenediol
9	18.480	0.35	Tetradecane (CAS) n-Tetradecane
10	18.992	0.65	2-undecene, 2,5-dimethyl- (CAS) 2,5-dimethyl-2-undecene
11	19.271	0.61	Pentadecane (CAS) n-Pentadecane
12	19.555	0.61	9-octadecenoic acid (Z)- (CAS) Oleic acid
13	19.767	0.45	Nonadecanol
14	20.017	0.83	Dodecane, 2,6,10-trimethyl- (CAS) Farnesane
15	20.218	1.56	Dodecanoic acid (CAS) Lauric acid
16	20.636	1.79	10-undecenoic acid, octyl ester (CAS) Octyl 10-undecenoate
17	20.892	2.24	Octadecanoic acid (CAS) Stearic acid
18	21.313	2.51	Docosanoic acid (CAS) Behenic acid
19	21.570	5.08	Tetradecanoic acid (CAS) Myristic acid
20	22.011	3.76	Pentadecanoic acid (CAS) Pentadecylic acid
21	22.226	5.34	Pentadecanoic acid (CAS) Pentadecylic acid
22	22.685	3.62	Hexadecanoic acid (CAS) Palmitic acid
23	22.975	14.04	Hexadecanoic acid (CAS) Palmitic acid
24	23.359	5.48	Heptadecanoic acid (CAS) Margaric acid
25	23.639	7.46	Heptadecanoic acid (CAS) Margaric acid
26	24.120	2.83	2(3H)-guranone, 5-dodecyldihydro- (CAS). gamma.-Palmitolactone
27	24.404	8.49	9-octadecenoic acid (Z)- (CAS) Oleic acid
28	24.795	6.29	Hexadecanamide (CAS) Amide 16
29	25.356	3.86	Nonadecanamide

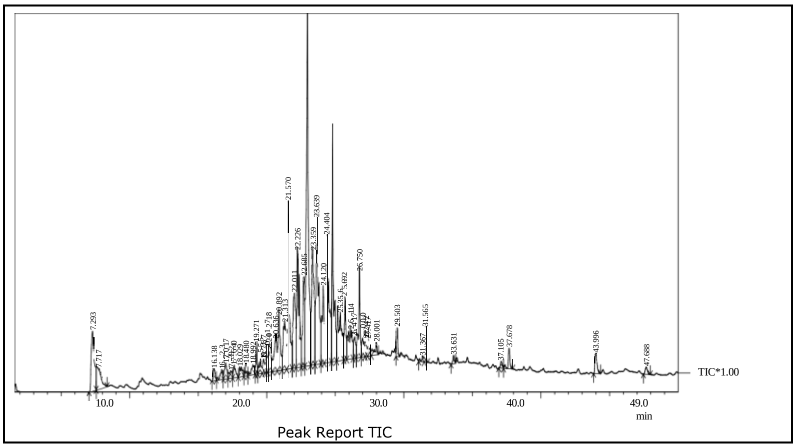

Figure 2. Total chromatogram of *Polymesoda erosa* meat from Jada Bahrin River of Bangka Regency.

In total, 29 VOCs were identified from kepah meat samples. Of these compounds, there were 1 aldehyde, 3 alcohols, 1 aromatic compound (furan), 1 ester, 14 fatty acids, 5 hydrocarbons, 2 ketones, 1 nitrogenous compound, and 1 oxygen-sulfur compound (Figure 3). The fatty acids were the most abundant compounds, including lauric acid, stearic acid, behenic acid, myristic acid, palmitic acid, margaric acid, oleic acid, and derivates such as hexadecanamide and nonadecanamide.

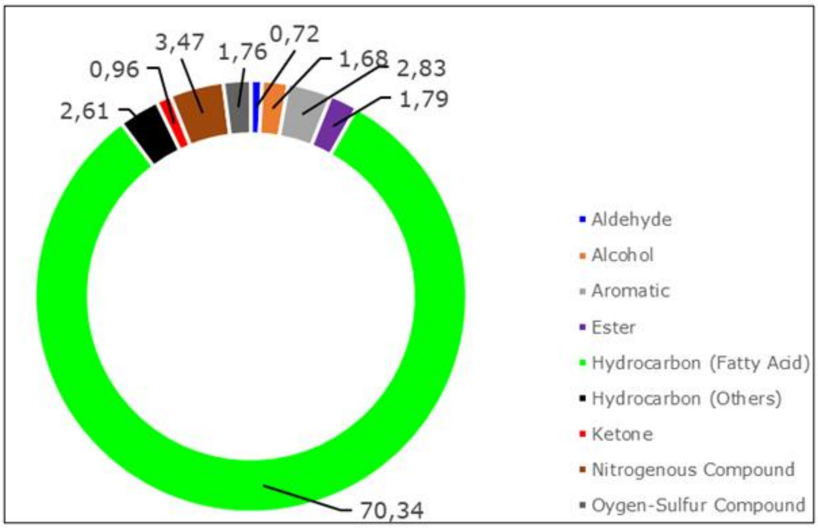

Figure 3. Total volatile compound groups of *Polymesoda erosa* meat.

P. erosa is a mollusc with a great nutritional potential, especially in fatty acids. Some of the saturated fatty acids (SFAs) from *P. erosa* are palmitic acid (C16:0), myristic acid (C14:0), lauric acid (C12:0), stearic acid (C18:0), behenic acid (C22:0), and

pentadecanoic acid (C15:0). Monounsaturated fatty acids (MUFA) are margaric acid (17:1) and oleic acid (C18:1n9c), as found in this research, but also by Leiwakabessy et al (2019). Polyunsaturated fatty acids from *P. erosa* were not found in this study.

We also analyzed VOCs of water from Jada Bahrin River. There were 28 VOCs detected in the water, with the highest concentration found at peak 26 with a retention time of 20.762 min, for 1,6-anhydro-Beta-D-Glucopyranose (Levoglucosan) (24.88%) (Table 2 and Figure 4). Latif et al (2012) explain Levoglucosan (1,6-anhidro-β-D-glucopyranose) is an organic molecule that can be used as an indicator for cellulose burning. Thus, it is possible that Levoglucosan from filter paper has contaminated the pyrolysis of VOCs.

Of the identified compounds, there were 6 aldehydes, 5 alcohols, 2 carbohydrates, 1 ester, 9 hydrocarbons, 4 ketones, and 1 protein (Figure 5). The hydrocarbons were the most abundant compound in the water. Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor, was the highest VOC found in the water of Jada Bahrin River, after Levoglucan (which was presumed to have contaminated the sample). Cyclopropane belongs to the class of organic compounds known as cycloalkanes, a group of hydrocarbons, found at peak 1 with a retention time of 6.486 min and a concentration of 19.41%.

Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor is an organic compound found in jabon (*Anthocephalus cadamba*) (Hadi et al 2021) and has antioxidant properties in young agarwood (*Aquilaria malaccensis* Lamk) leaves (Batubara et al 2021). Thus, we did not consider this VOC as a dangerous compound for the environment or for human health.

Table 2

Volatile organic compounds of water from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	6.486	19.41	Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor
2	8.260	3.24	2-methyl-3-oxo-Butyronitrile
3	9.025	0.50	Pentane (CAS) n-Pentane
4	9.412	2.98	Acetic acid (CAS) Ethylic acid
5	9.796	6.17	2-propanone, 1-hydroxy- (CAS) Acetol
6	11.591	0.43	2,3-pentanedione (CAS) 2,3-pentadione
7	11.825	1.07	Propanoic acid, 2-oxo-, methyl ester (CAS) Methyl pyruvate
8	12.179	0.77	1-cyano-6-hydroxypentane
9	12.594	0.53	2-furancarboxaldehyde (CAS) Furfural
10	13.156	0.35	2-propanone, 1-(acetyloxy)- (CAS) Acetol acetate
11	13.325	1.63	2-furanmethanol (CAS) Furfuryl alcohol
12	14.351	1.99	Cyclohexanone (CAS) Anon
13	14.525	1.47	2-furancarboxaldehyde, 5-methyl- (CAS) 5-methyl-2-furfural
14	15.562	1.91	2-cyclopenten-1-one, 2-hydroxy-3-methyl- (CAS) Corylon
15	15.988	1.71	Hydroxy Dimethyl Furanone
16	16.379	5.90	Pentanal (CAS) n-Pentanal
17	16.967	1.82	7-methyl-1,4-dioxaspiro[2.4]heptan-5-one
18	17.196	1.69	1-octene (CAS) Caprylene
19	17.561	2.62	Oxirane, 2-butyl-3-methyl- (CAS) 2,3-epoxyheptane
20	18.046	4.42	2-furancarboxaldehyde, 5-(hydroxymethyl)- (CAS) HMF
21	18.442	1.15	4-heptanol, 2,6-dimethyl-4-(1-methylethyl)- (CAS) 2,6-dimethyl-4-Isopro
22	18.912	3.11	Ethenol, 2-ethoxy-, acetate (CAS)
23	19.392	1.66	L-Glutamic acid, N-[(phenylmethoxy)carbonyl]-
24	19.667	2.52	2-propenoic acid, 2-methyl-, hexyl ester (CAS) Hexyl methacrylate
25	20.075	1.27	1-cyclohexene-1-carboxylic acid (CAS) 1-cyclohexenecarboxylic acid
26	20.762	24.88	1,6-anhydro-Beta-D-Glucopyranose (Levoglucosan)

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Peak	Retention time (min)	Concentration (%)	Name
27	21.775	2.44	1,6-anhydro-Beta-D-Glucofuranose
28	22.308	2.36	4-decenoic acid, methyl ester (CAS) Methyl dec-4-enoate

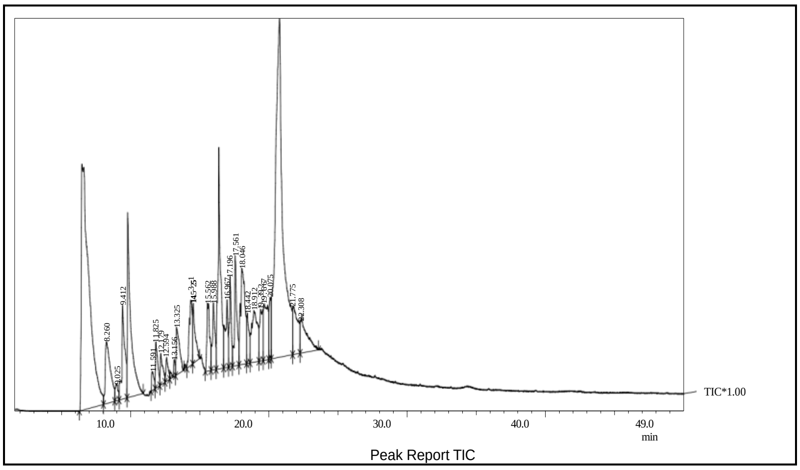

Figure 4. Total chromatogram of water from Jada Bahrin River of Bangka Regency.

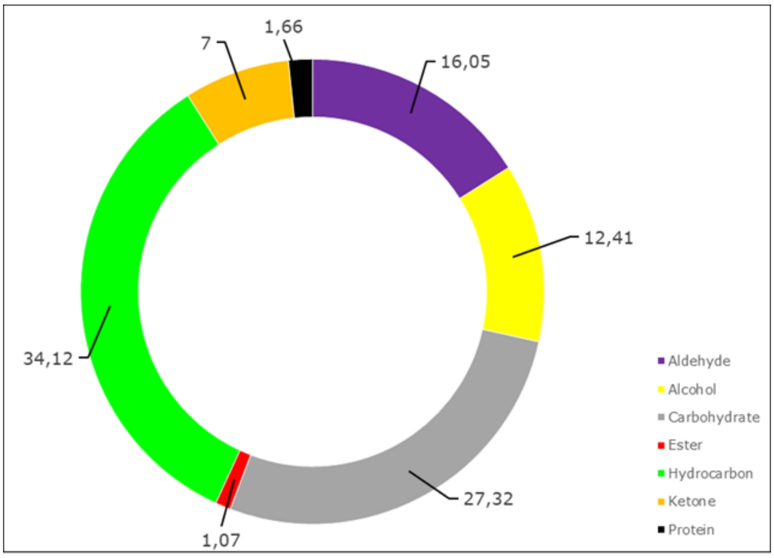

Figure 5. Total volatile compound groups in the water of Jada Bahrin River.

Sixty VOCs were detected in the sediment of Jada Bahrin River, with the highest concentration found at peak 50, with a retention time 41.694 min, for 1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene (6.36%) (Table 3 and Figure 6). Of the identified compounds, there were 1 aldehyde, 4 alcohols, 1 carbon dioxide, 6 esters, 45 hydrocarbons, and 3 ketones (Figure 7). The hydrocarbons were the most abundant compound type in the sediment. We found two VOC hydrocarbons that contain benzene, namely Benzofuran, 2,3-dihydro- (CAS) 2,3-Dihydrobenzofuran (R. Time 18.481 min, 1.48%) and 1H-Benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-, (R. Time 36.717 min, 0.58%).

Benzene is an aromatic hydrocarbon and a colorless and odorous liquid (Meckenstock et al 2016; Yildizhan et al 2021). It is formed from both natural processes and human activities. It is classified as carcinogen for humans, with effects such as acute leukemia and probably other hematological cancers. It is the primary starting material for chemicals used to make plastics, resins, synthetic fibers, nylons, dyes, detergents, drugs, pesticides, and also a component of crude oil (Smith 2010; Conte et al 2021). In the environment, this pollutant can be accumulated in organisms through direct or indirect routes. It is potentially accumulated in filter feeder organisms such as a clam.

Table 3

Volatile organic compounds of sediment from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	7.243	3.58	Carbon dioxide (CAS) Dry ice
2	17.642	0.53	10-undecenoic acid, Octyl ester (CAS) Octyl 10-Undecenoate
3	18.242	0.56	Nonanoic acid (CAS) Nonoic acid
4	18.481	1.48	Benzofuran, 2,3-dihydro- (CAS) 2,3-Dihydrobenzofuran
5	18.992	0.66	Decanoic acid (CAS) Capric acid
6	19.268	0.70	1-Octanol, 2-butyl- (CAS) 2-Butyl-1-octanol
7	19.492	0.32	2-Butanone, 4-cyclohexyl- (CAS) 4-Cyclohexyl-2-butanone
8	19.817	0.75	(1R*,6S*,10R*)-5,5-dimethyl-11,12-dioxatricyclo[8.2.1.0(1,6)]tridecan-10-ol
9	20.009	0.66	Hexadecane (CAS) n-Hexadecane
10	20.337	1.04	Docosanoic acid (CAS) Behenic acid
11	20.713	0.87	Tricosane (CAS) n-Tricosane
12	20.941	1.28	3-Hexadecene, (Z)- (CAS)
13	21.541	2.79	9-octadecenoic acid (Z)- (CAS) Oleic acid
14	21.867	0.47	2-undecanone, 6,10-dimethyl- (CAS) 6,10-dimethylundecan-2-one
15	22.067	2.35	Tetratetracontane (CAS) n-Tetratetracontane
16	23.015	4.98	Oxacycloheptadec-8-en-2-one (CAS) Ambrettolide
17	23.446	0.88	Pentatriacontane (CAS) n-Pentatriacontane
18	23.667	0.59	Megastigma-3,7(Z),9-triene
19	24.197	1.34	Pentatriacontane (CAS) n-Pentatriacontane
20	24.621	1.55	Oxacycloheptadec-8-en-2-one (CAS) Ambrettolide
21	25.026	1.16	Octadecane, 1-chloro- (CAS) 1-chlorooctadecane
22	25.974	0.40	Pentatriacontane (CAS) n-Pentatriacontane
23	26.891	0.69	Cyclododecanone (CAS) Cyclododecanon
24	27.067	0.37	Hexatriacontane (CAS) n-Hexatriacontane
25	27.973	0.60	1,2-Propanediol, 3-(Phenylmethoxy)-, Diacetate
26	28.388	0.52	Pentatriacontane (CAS) n-Pentatriacontane
27	29.667	1.22	Tetrapentacontane, 1,54-dibromo-
28	29.966	1.79	Tetratetracontane (CAS) n-Tetratetracontane
29	31.909	1.39	Pentatriacontane (CAS) n-Pentatriacontane
30	32.567	1.98	1-Hentetracontanol (CAS) N-Hentetracontanol-1
31	32.790	0.82	6-O-acetyl-7-desoxy-1,2:3,4:8,9:11,12-tetra-O-isopropyliden-7-nitro-.beta.-D-
32	33.117	1.05	Methyl Commate E
33	33.688	3.97	Nonacosanol (CAS)
34	34.060	1.81	Hexacosane, 9-octyl- (CAS) 9-n-Octylhexacosane
35	34.303	1.11	Pentatriacontane (CAS) n-Pentatriacontane
36	34.920	2.67	9,19-Cyclolanost-24-en-3-ol, Acetate

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Peak	Retention time (min)	Concentration (%)	Name
37	35.438	0.65	2-Pentadecanone, 6,10,14-trimethyl- (CAS) 6,10,14-Trimethyl-2-pentadecano
38	36.269	5.36	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy)trimethyl- (CAS) Cycl
39	36.717	0.58	1H-Benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-,
40	36.999	3.43	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy)trimethyl- (CAS) Cycl
41	37.474	1.18	Cycloeucalenol
42	37.817	1.48	Nonacosanol (CAS)
43	38.368	0.70	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy) trimethyl- (CAS) Cycl
44	38.590	0.79	Androst-5-en-3-ol, 4,4-dimethyl-, (3.beta.)- (CAS)
45	39.044	1.50	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
46	39.550	1.20	Cycloeucalenol
47	40.053	1.78	Androst-5-en-3-ol, Trifluoroacetate, (3.beta.)- (CAS)
48	40.639	2.68	13,27-Cycloursan-3-ol, Acetate, (3.Beta.,13.Beta.,14.Beta.)-
49	40.942	0.97	Tetracosane, 11-decyl- (CAS) 11-n-Decyltetracosane
50	41.694	6.36	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
51	42.132	3.08	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
52	42.629	3.31	4,4,6A,6B,8A,11,11,14B-octamethyl-1,4,4A,5,6,6A,6B,7,8,8A,9,10,11,12,
53	43.051	1.01	Norolean-12-ene
54	43.841	0.67	4,4,6A,6B,8A,11,11,14B-octamethyl-1,4,4A,5,6,6A,6B,7,8,8A,9,10,11,12,
55	44.417	0.57	9,19-cyclolanost-24-en-3-ol, Acetate
56	44.867	5.70	9,19-cyclolanost-24-en-3-ol, (3.beta.)- (CAS) Cycloartenol
57	45.517	0.68	Pentatriacontane (CAS) n-Pentatriacontane
58	45.828	2.30	6-isopropenyl-4,8A-dimethyl-3,5,6,7,8,8A-Hexahydro-1H-Naphth
59	46.399	1.22	9,19-cyclolanost-24-en-3-ol, (3.beta.)- (CAS) Cycloartenol
60	47.407	3.86	14-.Beta.-H-Pregna

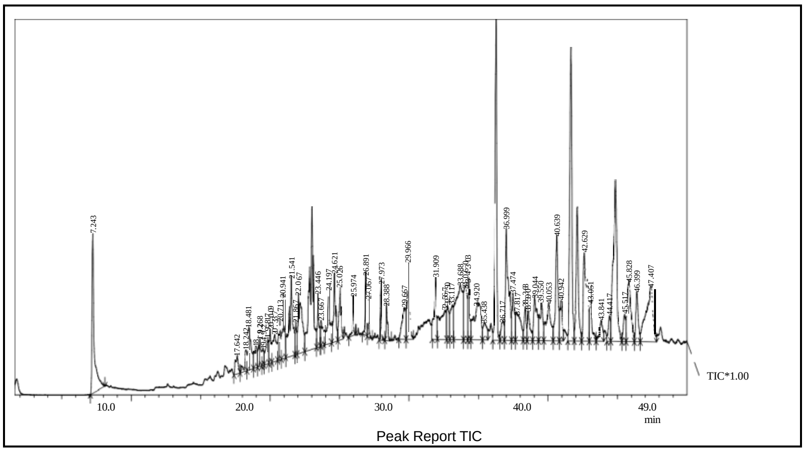

Figure 6. Total chromatogram of sediment from Jada Bahrin River of Bangka Regency.

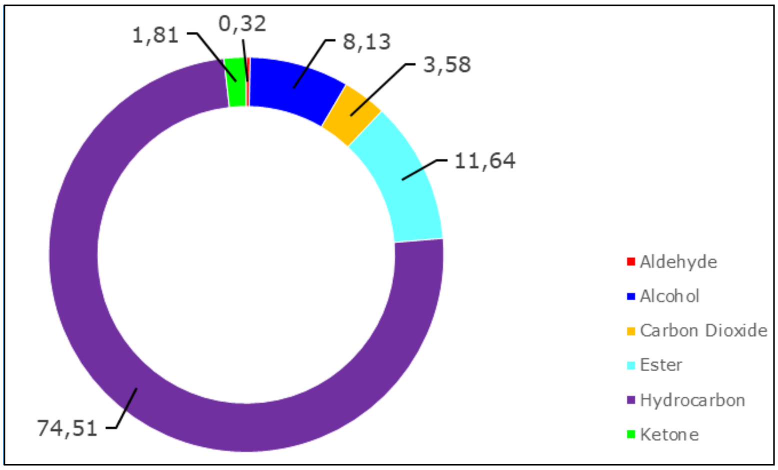

Figure 3. Total volatile compound groups of sediment from Jada Bahrin River.

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Benzene accumulation has been observed in *Gafrarium divaricatum*, with concentration between 4.35 and 8.70 mg L^{-1}. Chronic exposure of clams to benzene resulted in loss of bubbling epithelium, separation and necrosis of epithelial cells, reduction in cytoplasm volume and density, fusion of cell membranes, disruption of the inner lining of tubules, and nuclei forming darkly stained areas at basal part of the cells (Agwuocha et al 2011). The presence of benzene in the environment at a concentration of 5.69 μL L^{-1} also affects the physiological processes of mussels, *Perna perna*, reducing oxygen consumption and ammonia excretion (Jorge et al 2007). Furthermore, aromatic hydrocarbon pollutants such as benzene, toluene, and xylene (BTX) contribute to damaging DNA in the bivalve *Corbicula fluminea* (Fedato et al 2010). In this research, we did not obtain benzene contaminated kepah meat in Jada Bahrin River. However, compounds that contain benzene were found in the sediment, so the potential contamination with benzene and its derivates should be considered in future studies.

Overall, this study described that *P. erosa* can be used as bioindicator of organic pollutants such as volatile organic compounds, as well as statement of Mendoza et al (2019). VOCs found in meat of kepah represented potential of pollutant from the habitats due to the clam are capable to accumulate pollutants in the environment into their body tissue (Nuryanto & Sastranegara 2013). In this study, we found component of VOCs contain benzene in sediment and we indicated benzene will be persistent (Jenneskens et al 2011). Furthermore, we must monitor the presence of benzene that accumulated in kepah. We consider the potential of toxicity effect for human health such as carcinogen, acute and chronic diseases, nervous system disease, the reproductive and developmental system, the immune system and the respiratory system, and hematological diseases (Falzone et al 2016; Dettenrieder et al 2020).

Conclusions. We have confirmed Pyr-GC/MS as an applicable instrument for determining volatile organic compounds (VOCs) in kepah meat, water and sediment. Hydrocarbons were the most abundant compound in kepah meat, water, and sediment, collected from Jada Bahrin River, Bangka Regency, Bangka Island, Indonesia.

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Conflict of Interest. The authors declare that there is no conflict of interest.

References

Agwuocha S., Kulkarni B. G., Pandey A. K., 2011 Histopathological alterations in hepatopancreas of *Gafrarium divaricatum* exposed to xylene, benzene and gear oil-WSF. Journal of Environmental Biology 32(1):35-38.

Argente F. A. T., 2016 Bivalve superpower: the global invasion of corbiculid clams. Annual Research & Review in Biology 10(3):1-10.

Batubara R., Hanum T. I., Affandi O, 2021 GC-MS analysis of young and mature wild agarwood leaves (*Aquilaria malaccensis* Lamk) and its antioxidant potential. IOP Conference Series: Earth and Environmental Science 912:012038.

Biona M. A., Marte C. R., Pasadilla A. L. G., Araneta, B. Y. G., 2017 Estimation of the edible wet tissue weight of the mangrove clam *Polymesoda erosa* harvested from the wild. PEERS Inc. Multidisciplinary Research Journal 1(1):1-9.

Bouzid N., Anquetil C., Dris R., Gasperi J., Tassin B., Derenne S., 2022 Quantification of microplastics by pyrolysis coupled with gas chromatography and mass spectrometry in sediments: Challenges and implications. Microplastics 1(2):229-239.

Bravo-Linares C. M., Mudge S. M., Loyola-Sepulveda R. H., 2010 Production of volatile organic compounds (VOCs) by temperate macroalgae: The use of Solid Phase Microextraction (SPME) coupled to GC-MS as method of analysis. Journal of the Chilean Chemical Society 55(2):227-232.

Cheng S., Zhang J., Wang Y., Zhang D., Teng G., Chang-Chien G. P., Qianli H., Zhang Y. B., Yan P., 2019 Global research trends in health effects of volatile organic compounds during the last 16 years: a bibliometric analysis. Aerosol and Air Quality Research 19(8):1834-1843.

Clemente S., Ingole B., 2011 Recruitment of mud clam *Polymesoda erosa* (Solander, 1876) in a mangrove habitat of Chorao Island, Goa. Brazilian Journal of Oceanography 59(2):153-162.

Conte S., Lagacé F., Netchiporouk E., Sasseville D., Litvinov I. V., 2021 Benzene, a known human carcinogen, detected in suncare products. Journal of Cutaneous Medicine and Surgery 25(6):650-651.

David E., Niculescu V. C., 2021 Volatile organic compounds (VOCs) as environmental pollutants: occurrence and mitigation using nanomaterials. International Journal of Environmental Research and Public Health 18(24):13147.

Dettenrieder C., Türkmen D., Mattsson A., Österlund L., Karlsson M., Mizaikoff B., 2020 Determination of volatile organic compounds in water by attenuated total reflection infrared spectroscopy and diamond-like carbon coated silicon wafers. Chemosensors 8(3):75.

Ding J., Sun C., He C., Li J., Ju P., Li F., 2021 Microplastics in four bivalve species and basis for using bivalves as bioindicators of microplastic pollution. Science of The Total Environment 782:146830.

Dini J. W., 2008 Volatile organic compounds in foods and beverages. Plating and Surface Finishing 95(5):14-15.

Falzone L., Marconi A., Loreto C., Franco S., Spandidos D. A., Libra M., 2016. Occupational exposure to carcinogens: Benzene, pesticides and fibers. Molecular medicine reports 14(5): 4467-4474.

Fedato R. P., Simonato J. D., Martinez C. B. R., Sofia S. H., 2010 Genetic damage in the bivalve mollusk *Corbicula fluminea* induced by the water-soluble fraction of gasoline. Mutation Research/Genetic Toxicology and Environmental Mutagenesis 700(1-2):80-85.

Genovese A., Marrazzo A., De Luca L., Romano R., Manzo N., Masucci F., Di Francia A., Sacchi R., 2019 Volatile organic compound and fatty acid profile of milk from cows and buffaloes fed mycorrhizal or nonmycorrhizal ensiled forage. Molecules 24(8):1616.

Hadi Y. S., Nawawi D. S., Abdillah I. B., Pari G., Pari R., 2021 Evaluation of discoloration and subterranean termite resistance of four furfurylated tropical wood species after one-year outdoor exposure. Forests 12(7):900.

Hamli H., Rahim A. A., Idris M. H., Kamal A. H. M., King W. S., 2015 Morphometric variation among three local mangrove clam species of Corbiculidae. Songklanakarin Journal of Science and Technology 37(1):15-20.
Jenneskens L. W., Havenith R. W., Soncini A., Fowler P. W., 2011. Aromaticity of strongly bent benzene rings: persistence of a diatropic ring current and its shielding cone in [5] paracyclophane. Physical Chemistry Chemical Physics 13(37): 16861-16866.
Jorge R. A. D. L. V. C., Lemos D., Moreira G. S., 2007 Effect of zinc and benzene on respiration and excretion of mussel larvae (*Perna perna*) (Linnaeus, 1758) (Mollusca; Bivalvia). Brazilian Journal of Biology 67(1):111-115.
Juang D. E., Yuan C. S., Hsueh S. C., Chiou L. J., 2009 Distribution of volatile organic compounds around a polluted river. International Journal of Environmental Science & Technology 6(1):91-104.
Latif M. T., Mei C. S., Hanif N. M., Srithawirat T., 2012 Levoglucosan as an indicator of biomass burning from selected tropical plants. EnvironmentAsia 5(2):22-27.
Leiwakabessy J., Nanlohy E. E., Lewerissa S., 2019 Fatty acid profile of some fresh and dried molluscs in Central Maluku, Indonesia. AACL Bioflux 12(4):1189-1195.
Meckenstock R. U., Boll M., Mouttaki H., Koelschbach J. S., Tarouco P. C., Weyrauch P., Dong X., Himmelberg A. M., 2016 Anaerobic degradation of benzene and polycyclic aromatic hydrocarbons. Microbial Physiology 26(1-3):92-118.
Mendoza D. M., Mula M. G., Baysa R. P., 2019 Spatial density, size, growth and condition index of mangrove clam (*Polymesoda erosa*) in the estuarine portion of Pasak River, Sasmuan, Pampanga, Philippines. International Journal of Fisheries and Aquatic Studies 7(4):258-262.
Montero-Montoya R., López-Vargas R., Arellano-Aguilar O., 2018 Volatile organic compounds in air: sources, distribution, exposure and associated illnesses in children. Annals of Global Health 84(2):225-238.
Mustapha S. H. B., 2020 [Microplastic contamination in mollusc Polymesoda]. Dissertation, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor, 64 p. [In Malay].
Mutić J., Jovanović V., Jacxsens L., Tondeleir J., Ristivojević P., Djurdjić S., Rajković A., Veličković T. Ć., 2021 Chemical content of five molluscan bivalve species collected from South Korea: multivariate study and safety evaluation. Foods 10(11):2690.
Nuryanto A., Sastranegara M. H., 2013 Molecular characterisation of *Polymesoda erosa* (Solander, 1786) inhabit two different habitats. Bionatura-Jurnal Ilmu-ilmu Hayati dan Fisik 15(3):184-189.
Peters C. A., Hendrickson E., Minor E. C., Schreiner K., Halbur J., Bratton S. P., 2018 Pyr-GC/MS analysis of microplastics extracted from the stomach content of benthivore fish from the Texas Gulf Coast. Marine Pollution Bulletin 137:91-95.
Smith M. T., 2010 Advances in understanding benzene health effects and susceptibility. Annual Review of Public Health 31:133-148.
Vinci R. M., Jacxsens L., De Meulenaer B., Deconink E., Matsiko E., Lachat C., de Schaetzen T., Canfyn M., Van Overmeire I., Kolsteren P., van Loco J., 2015 Occurrence of volatile organic compounds in foods from the Belgian market and dietary exposure assessment. Food Control 52:1-8.
Wang R., Mou H., Lin X., Zhu H., Li B., Wang J., Junaid M., Wang J., 2021 Microplastics in mollusks: research progress, current contamination status, analysis approaches, and future perspectives. Frontiers in Marine Science 1671(8):759919.
Wang Q., Wang C., Hou L., Lv B., Chén W. A. N. G., 2018 Pollution data analysis and characteristics of volatile organic compounds in the environment. E3S Web of Conferences 38:01004, 5 p.
Yadav R., Pandey P., 2018 A review on volatile organic compounds (VOCs) as environmental pollutants: fate and distribution. International Journal of Plant and Environment 4(2):14-26.
Yildizhan E., Koyutürk L. C., Akkuş M., Tektemur N. K., Özkorkmaz E. G., Fırat A. Ş. I. R., 2021 Examination of apoptotic changes in aromatic hydrocarbon benzene administered rat testicular tissue with histopathological methods. Middle East Journal of Science 7(1):1-10.

Yusoff A. H., Roslan N. N., Chang C. S., Lazim A. M., Nadzir M. S. M., Oslan S. N. H., Sulaiman A. Z., Ahmed M. F., Mohamed M., Zakaria K. A., Tan R., 2021 Heavy metals in marsh clam (*Polymesoda expansa*) as bioindicators for pollution in industrial and sand mining area of Kelantan River Basin, Malaysia. Trends in Sciences 18(20):1-10.
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Profile of volatile organic compounds in kepah (*Polymesoda erosa* Solander, 1786) collected from Jada Bahrin River of Bangka Island, Indonesia

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Abstract. This study aimed to provide information about the profile of volatile organic compounds (VOCs) in kepah (*Polymesoda erosa* Solander, 1786), and also about sediment and water of their habitat in Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia. The analysis of VOCs was carried out using Pyrolysis-GC/MS analysis. A number of volatile organic compounds (VOCs) were measured, including aldehydes, alcohols, aromatic compounds, carbohydrates, carbon dioxide, esters, hydrocarbons, ketones, nitrogenous compounds, oxygen-sulfur compounds, and proteins. We have found that 29 VOCs were detected in kepah meat. Hexadecanoic acid (CAS) (palmitic acid) had the highest concentration, 14.04%. We also found 28 VOCs in the water. Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-dibromo-2-chlor had the highest concentration, namely 19.41%. Furthermore, there were 60 VOCs that detected in sediment, with the highest concentration for 1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene (6.36%).
Key Words: clam, degradation, organic chemical, pyrolysis-GC/MS.

Introduction. Volatile organic compounds (VOCs) are large groups of organic chemical compounds found in many products. They vaporize easily and enter the environment under normal conditions (Yadav & Pandey 2018). VOCs are defined by the US Environmental Protection Agency (U.S. EPA), as organic compounds with low initial boiling point (less than or equal to 250°C) at a standard atmospheric pressure of 101.3 kPa (Cheng et al 2019). Wang et al (2018) define VOCs as volatile organic compounds with higher saturated vapor pressure (greater than or equal to 0.01 kPa at 20°C), low boiling point, and small molecular weight. VOCs include into non-methane hydrocarbons such as alkanes, alkenes, alkynes and aromatic hydrocarbons (NMHCs), oxygen containing organic compounds including aldehydes, ketones, alcohols, ethers and halogenated hydrocarbons (OVOCs), nitrogenous compounds, sulfur compounds and other compounds.

VOCs are ubiquitous in the environment and they may represent health risks. VOCs are derived from natural and human activities. Naturally, VOCs can be produced by macroalgae in response to environmental stresses and also from plants. VOCs generated by anthropogenic activities come from both domestic and industrial processes (Bravo-Linares et al 2010; David & Niculescu 2021). Since the industrial waste around the river could contain some hazardous VOCs that might affect the health of living organisms in the water and can enter the human body via food chain pathways. They can lead to symptoms and pathologies in the respiratory tract, nervous system, skin, kidneys and others. Some VOCs like benzene, 1,3-butadiene, and vinyl chloride are classified by the International Agency for Research on Cancer (IARC) in Group 1 as carcinogenic for humans (Juang et al 2009; Montero-Montoya et al 2018). On the other hand, VOCs in foods provide a flavor fingerprint that help humans recognize appropriate foods and avoid poor or dangerous foods (Dini 2008). The group of VOCs such as ethyl esters, aldehydes, nitrogen compounds, ketones, alcohols, and dimethylsulphone, represent the main aromatic constituents of foods (Genovese et al 2019). Thus, it is important to understand their presence in the environment and especially in our diet and to identify possible sources of VOCs (Vinci et al 2015).

Argente (2016) explains that there are three genera within the Family Corbiculidae, which are distributed worldwide, namely *Batissa*, *Polymesoda*, and *Corbicula*. Hamli et al (2015) explain there are three common species of the genus *Polymesda* from the family Corbiculidae, class Bivalvia that can be found inhabiting the mangrove areas in Southeast Asia, namely *P. erosa*, *P. bengalensis*, and *P. expansa*. The mud or mangrove clam (*Polymesoda erosa* Solander, 1786), with the local name 'kepah' in Bangka Island, is an edible bivalve species. *P. erosa* can be found in intertidal areas, in mangrove substrate and in the fresh and brackish waters of mangrove swamps, estuaries, and larger rivers (Biona et al 2017). Molluscs have high economic value and reproduce easily. In addition, they are highly nutritious and are considered an excellent source of proteins, lipids and minerals. Molluscs are a highly valuable aquaculture resource, and mussels in particular are typical filter feeders, constantly filtering substances out of the surrounding water (Wang et al 2021). *Polymesoda* sp. feed by filtering suspended particles in the water that surrounds them (Mustapha 2020). Bivalves are well known as filter feeders for suspended particles within water columns that may be contaminated with numerous pollutants from anthropogenic activities or natural factors (Yusoff et al 2021). Therefore, they can be a potential source of organic and inorganic environmental pollutants that accumulate in the body and are transmitted to humans through consumption (Ding et al 2021; Mutić et al 2021).

This study aimed to provide information related to the volatile organic compounds from the meat of kepah, sediment and water collected from Jada Bahrin River, Bangka Regency, Bangka Island, Indonesia.

Material and Method. This research took place from May to June 2022. The study was conducted by testing volatile organic compounds from samples (kepah, sediment, and water), collected from Jada Bahrin River, located in Bangka Regency, Bangka Island, Indonesia. We have sampled randomly 20 individuals of kepah, 1.5 L of water, and 100 g of sediment. The habitat of kepah in the area of sampling was represented by the mud around mangrove trees. The identification of kepah was done using as reference www.sealifebase.ca. Collected samples were stored in a cold box with at less than 5^oC to prevent the decrease in VOC content. Kepah (0.05 mg), sediment (0.05 mg), and water of river (0.05 mg) were used as samples in this study.

The VOCs were determined using Pyrolysis Gas Chromatography–Mass Spectrometry (pyr-GC/MS) (Peters et al 2018; Bouzid et al 2022). Patoni et al (2022) explain that qualitative and quantitative analysis of volatile compounds was measured using the GCMS Pyrolysis Shimadzu GCMS-QP 2010, with a column length (rt x 5 ms) 60 m, 0.25 mm in diameter and 0.25 m thickness. The initial column oven temperature was held at 50°C for 5 min and increased by 2.5°C min^{-1} to 150°C, and finally with 90°C min^{-1} to 280°C. In pyrolysis, it was set at 600°C. Gas Chromatography was set at a pressure of 101.0 kPa, total flow 46.5 mL min^{-1}, column flow 0.85 mL min^{-1}, with a linear velocity of 23.7 cm sec^{-1}. The ion source temperature and the interface temperature were maintained at 200 and 280°C, respectively, with a split ratio of 1:50 with 1 mL of sample injected. Some VOCs were investigated and presented in chromatograms, while name and retention time (R. time) of total ion chromatography (TIC) was based on peaks of chromatograms. The results of GCMS-Pyrolysis analysis were analyzed and tabulated using the Wiley 7 program.

Results and Discussion. Kepah collected from Jada Bahrin River are presented in Figure 1. 29 VOCs were detected in kepah meat with the highest concentration found at peak 23 with a retention time of 22.975 min for hexadecanoic acid (CAS) (palmitic acid - 14.04%) (Table 1 and Figure 2).

Figure 1. *Polymesoda erosa* from Jada Bahrin River of Bangka Regency, Indonesia; a - collection process; b - kepah after collection; c - kepah in the laboratory.

Table 1
Volatile organic compounds of *Polymesoda erosa* meat from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	7.293	3.47	Nitrogen oxide (N_2O) (CAS) Nitrous oxide
2	7.717	1.76	1,4-oxathiane, 4,4-dioxide (CAS) p-Thioxane sulfone
3	16.138	0.43	2-cyclopenten-1-one, 2-hydroxy-3-methyl- (CAS) Corylon
4	16.723	0.49	Isooctane, (ethenyloxy)- (CAS) Isooctyl Vinyl Ether
5	17.017	0.72	Pentanal (CAS) n-Pentanal
6	17.392	0.40	1,3-pentanediol, 2,2,4-trimethyl- (CAS) 2,2,4-trimethyl-1,3-pentanediol
7	17.640	0.51	Decane, 2,3,5,8-Tetramethyl-
8	18.029	0.53	2-butene-1,4-diol, (Z)- (CAS) cis-Butenediol
9	18.480	0.35	Tetradecane (CAS) n-Tetradecane
10	18.992	0.65	2-undecene, 2,5-dimethyl- (CAS) 2,5-dimethyl-2-undecene
11	19.271	0.61	Pentadecane (CAS) n-Pentadecane
12	19.555	0.61	9-octadecenoic acid (Z)- (CAS) Oleic acid
13	19.767	0.45	Nonadecanol
14	20.017	0.83	Dodecane, 2,6,10-trimethyl- (CAS) Farnesane
15	20.218	1.56	Dodecanoic acid (CAS) Lauric acid
16	20.636	1.79	10-undecenoic acid, octyl ester (CAS) Octyl 10-undecenoate
17	20.892	2.24	Octadecanoic acid (CAS) Stearic acid
18	21.313	2.51	Docosanoic acid (CAS) Behenic acid
19	21.570	5.08	Tetradecanoic acid (CAS) Myristic acid
20	22.011	3.76	Pentadecanoic acid (CAS) Pentadecylic acid
21	22.226	5.34	Pentadecanoic acid (CAS) Pentadecylic acid
22	22.685	3.62	Hexadecanoic acid (CAS) Palmitic acid
23	22.975	14.04	Hexadecanoic acid (CAS) Palmitic acid
24	23.359	5.48	Heptadecanoic acid (CAS) Margaric acid
25	23.639	7.46	Heptadecanoic acid (CAS) Margaric acid
26	24.120	2.83	2(3H)-guranone, 5-dodecyldihydro- (CAS). gamma.-Palmitolactone
27	24.404	8.49	9-octadecenoic acid (Z)- (CAS) Oleic acid
28	24.795	6.29	Hexadecanamide (CAS) Amide 16
29	25.356	3.86	Nonadecanamide

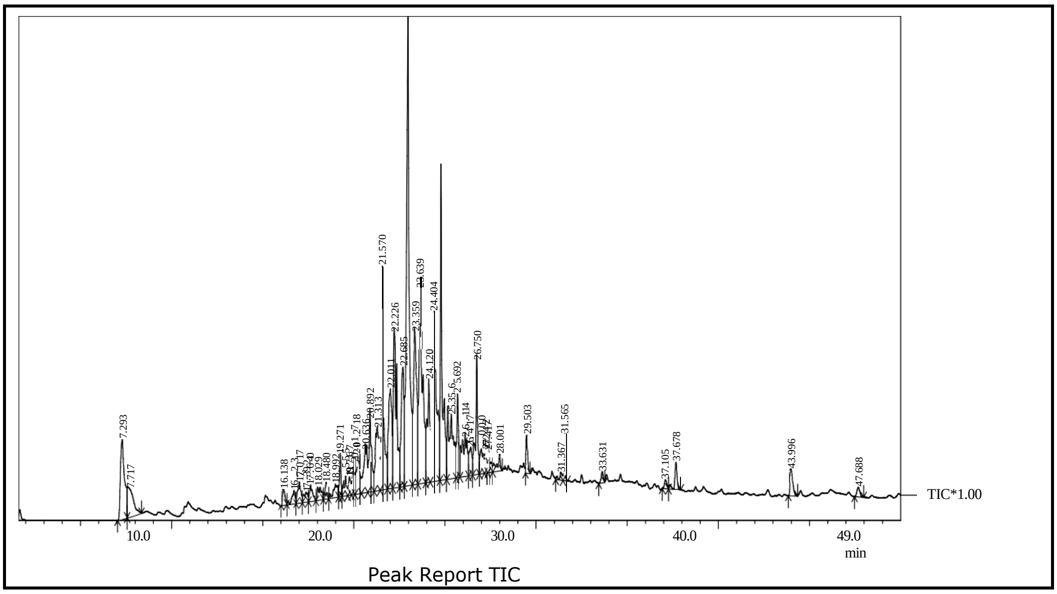

Figure 2. Total chromatogram of *Polymesoda erosa* meat from Jada Bahrin River of Bangka Regency.

In total, 29 VOCs were identified from kepah meat samples. Of these compounds, there were 1 aldehyde, 3 alcohols, 1 aromatic compound (furan), 1 ester, 14 fatty acids, 5 hydrocarbons, 2 ketones, 1 nitrogenous compound, and 1 oxygen-sulfur compound (Figure 3). The fatty acids were the most abundant compounds, including lauric acid, stearic acid, behenic acid, myristic acid, palmitic acid, margaric acid, oleic acid, and derivates such as hexadecanamide and nonadecanamide.

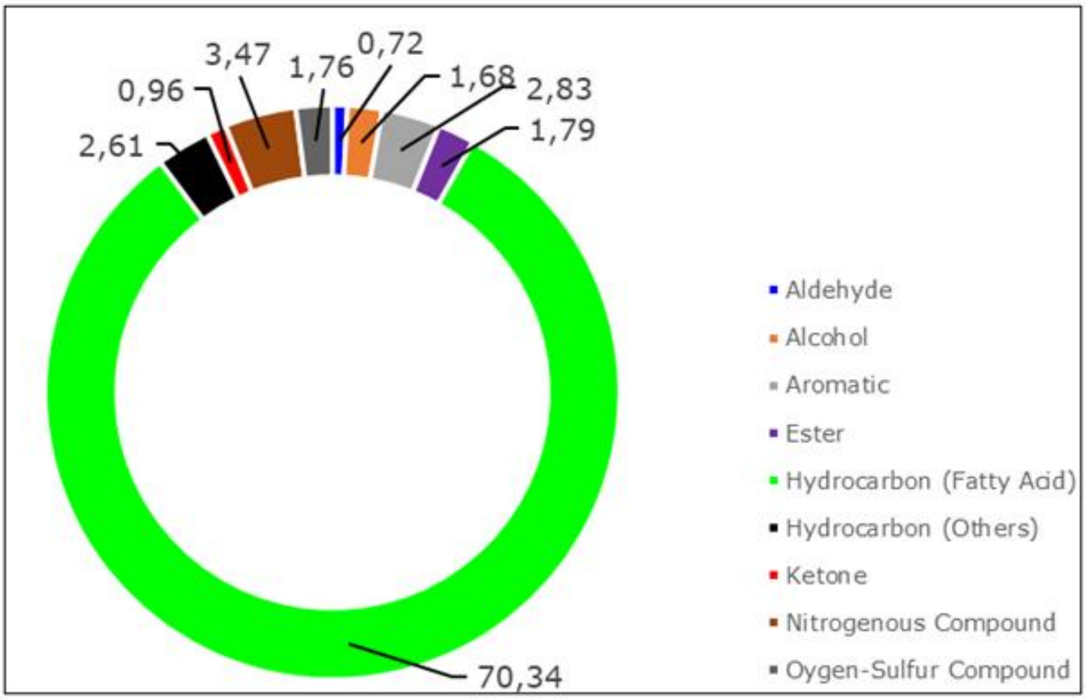

Figure 3. Total volatile compound groups of *Polymesoda erosa* meat.

P. erosa is a mollusc with a great nutritional potential, especially in fatty acids. Some of the saturated fatty acids (SFAs) from *P. erosa* are palmitic acid (C16:0), myristic acid (C14:0), lauric acid (C12:0), stearic acid (C18:0), behenic acid (C22:0), and

pentadecanoic acid (C15:0). Monounsaturated fatty acids (MUFA) are margaric acid (17:1) and oleic acid (C18:1n9c), as found in this research, but also by Leiwakabessy et al (2019). Polyunsaturated fatty acids from *P. erosa* were not found in this study.

We also analyzed VOCs of water from Jada Bahrin River. There were 28 VOCs detected in the water, with the highest concentration found at peak 26 with a retention time of 20.762 min, for 1,6-anhydro-beta-D-glucopyranose (levoglucosan) (24.88%) (Table 2 and Figure 4). Latif et al (2012) explain levoglucosan (1,6-anhidro-β-D-glucopyranose) is an organic molecule that can be used as an indicator for cellulose burning. Thus, it is possible that levoglucosan from filter paper has contaminated the pyrolysis of VOCs.

Of the identified compounds, there were 6 aldehydes, 5 alcohols, 2 carbohydrates, 1 ester, 9 hydrocarbons, 4 ketones, and 1 protein (Figure 5). The hydrocarbons were the most abundant compound in the water. Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-dibromo-2-chlor, was the highest VOC found in the water of Jada Bahrin River, after levoglucan (which was presumed to have contaminated the sample). Cyclopropane belongs to the class of organic compounds known as cycloalkanes, a group of hydrocarbons, found at peak 1 with a retention time of 6.486 min and a concentration of 19.41%.

Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-dibromo-2-chlor is an organic compound found in jabon (*Anthocephalus cadamba*) (Hadi et al 2021) and has antioxidant properties in young agarwood (*Aquilaria malaccensis* Lamk) leaves (Batubara et al 2021). Thus, we did not consider this VOC as a dangerous compound for the environment or for human health.

Table 2

Volatile organic compounds of water from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	6.486	19.41	Cyclopropane, 1,1-dibromo-2-chloro-2-fluoro- (CAS) 1,1-Dibromo-2-Chlor
2	8.260	3.24	2-methyl-3-oxo-Butyronitrile
3	9.025	0.50	Pentane (CAS) n-Pentane
4	9.412	2.98	Acetic acid (CAS) Ethylic acid
5	9.796	6.17	2-propanone, 1-hydroxy- (CAS) Acetol
6	11.591	0.43	2,3-pentanedione (CAS) 2,3-pentadione
7	11.825	1.07	Propanoic acid, 2-oxo-, methyl ester (CAS) Methyl pyruvate
8	12.179	0.77	1-cyano-6-hydroxypentane
9	12.594	0.53	2-furancarboxaldehyde (CAS) Furfural
10	13.156	0.35	2-propanone, 1-(acetyloxy)- (CAS) Acetol acetate
11	13.325	1.63	2-furanmethanol (CAS) Furfuryl alcohol
12	14.351	1.99	Cyclohexanone (CAS) Anon
13	14.525	1.47	2-furancarboxaldehyde, 5-methyl- (CAS) 5-methyl-2-furfural
14	15.562	1.91	2-cyclopenten-1-one, 2-hydroxy-3-methyl- (CAS) Corylon
15	15.988	1.71	Hydroxy Dimethyl Furanone
16	16.379	5.90	Pentanal (CAS) n-Pentanal
17	16.967	1.82	7-methyl-1,4-dioxaspiro[2.4]heptan-5-one
18	17.196	1.69	1-octene (CAS) Caprylene
19	17.561	2.62	Oxirane, 2-butyl-3-methyl- (CAS) 2,3-epoxyheptane
20	18.046	4.42	2-furancarboxaldehyde, 5-(hydroxymethyl)- (CAS) HMF
21	18.442	1.15	4-heptanol, 2,6-dimethyl-4-(1-methylethyl)- (CAS) 2,6-dimethyl-4-Isopro
22	18.912	3.11	Ethenol, 2-ethoxy-, acetate (CAS)
23	19.392	1.66	L-Glutamic acid, N-[(phenylmethoxy)carbonyl]-
24	19.667	2.52	2-propenoic acid, 2-methyl-, hexyl ester (CAS) Hexyl methacrylate
25	20.075	1.27	1-cyclohexene-1-carboxylic acid (CAS) 1-cyclohexenecarboxylic acid
26	20.762	24.88	1,6-anhydro-Beta-D-Glucopyranose (Levoglucosan)

Table 2
Volatile organic compounds of water from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia (continuation)

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
27	21.775	2.44	1,6-anhydro-Beta-D-Glucofuranose
28	22.308	2.36	4-decenoic acid, methyl ester (CAS) Methyl dec-4-enoate

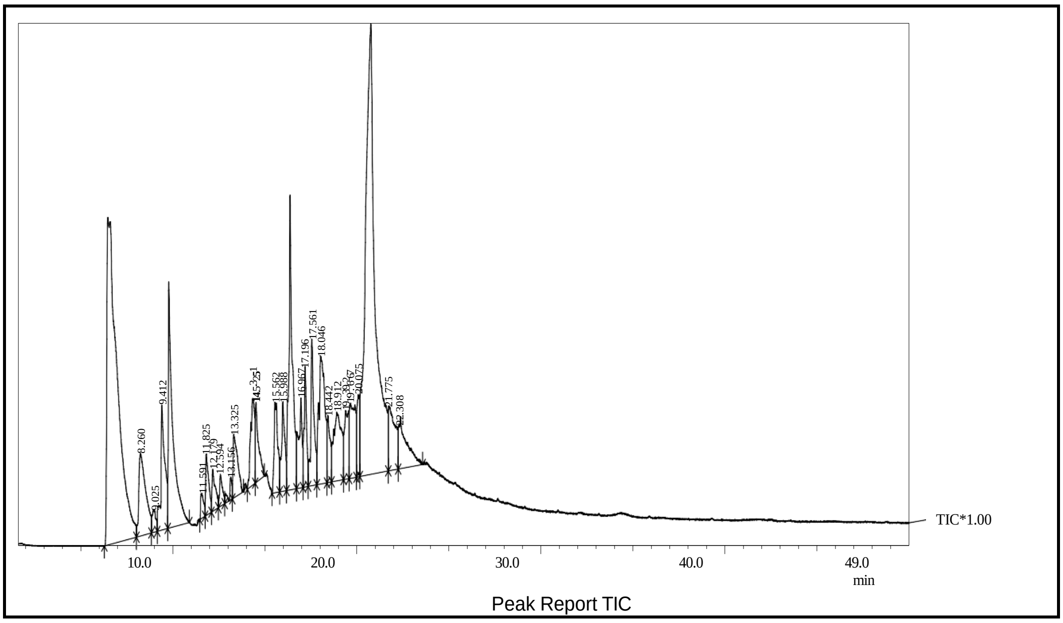

Figure 4. Total chromatogram of water from Jada Bahrin River of Bangka Regency.

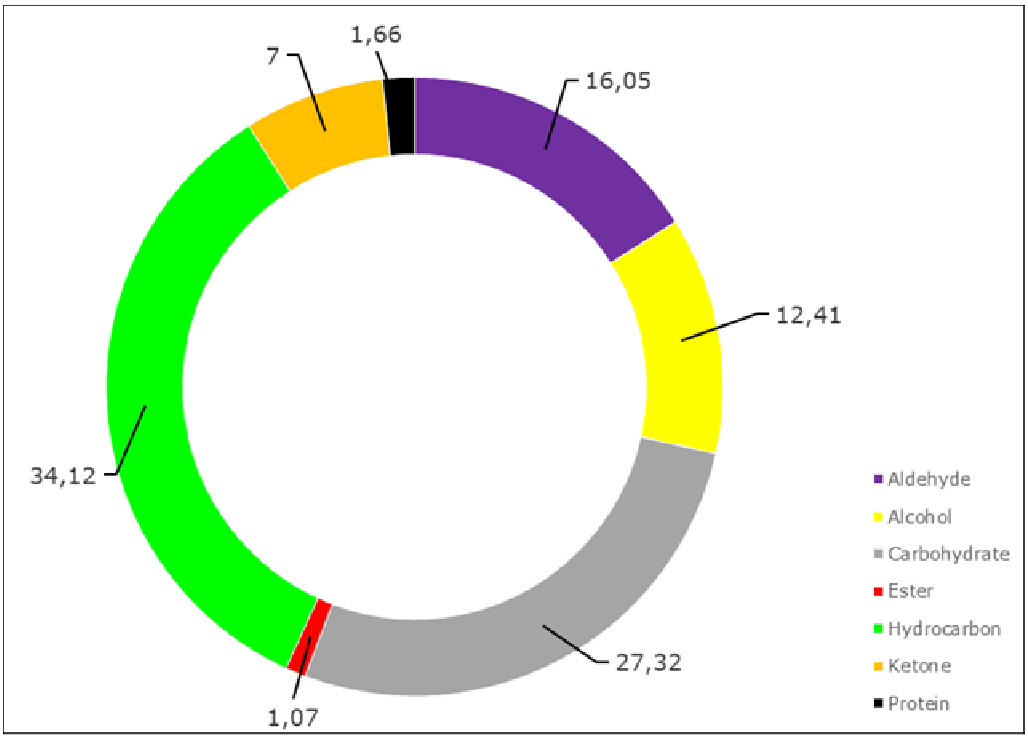

Figure 5. Total volatile compound groups in the water of Jada Bahrin River.

Sixty VOCs were detected in the sediment of Jada Bahrin River, with the highest concentration found at peak 50, with a retention time 41.694 min, for 1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene (6.36%) (Table 3 and Figure 6). Of the identified compounds, there were 1 aldehyde, 4 alcohols, 1 carbon dioxide, 6 esters, 45 hydrocarbons, and 3 ketones (Figure 7). The hydrocarbons were the most abundant compound type in the sediment. We found two VOC hydrocarbons that contain benzene, namely benzofuran, 2,3-dihydro- (CAS) 2,3-dihydrobenzofuran (R. time 18.481 min, 1.48%) and 1H-benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-, (R. time 36.717 min, 0.58%).

Benzene is an aromatic hydrocarbon and a colorless and odorous liquid (Meckenstock et al 2016; Yildizhan et al 2021). It is formed from both natural processes and human activities. It is classified as carcinogen for humans, with effects such as acute leukemia and probably other hematological cancers. Benzene is a major raw material used to make plastics, resins, synthetic fibers, nylons, dyes, detergents, pharmaceuticals and pesticides, and is also a component of crude oil (Smith 2010; Conte et al 2021). In the environment, this pollutant can be accumulated in organisms through direct or indirect routes. It is potentially accumulated in filter feeder organisms such as a clams.

Table 3

Volatile organic compounds of sediment from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
1	7.243	3.58	Carbon dioxide (CAS) Dry ice
2	17.642	0.53	10-undecenoic acid, Octyl ester (CAS) Octyl 10-Undecenoate
3	18.242	0.56	Nonanoic acid (CAS) Nonoic acid
4	18.481	1.48	Benzofuran, 2,3-dihydro- (CAS) 2,3-Dihydrobenzofuran
5	18.992	0.66	Decanoic acid (CAS) Capric acid
6	19.268	0.70	1-Octanol, 2-butyl- (CAS) 2-Butyl-1-octanol
7	19.492	0.32	2-Butanone, 4-cyclohexyl- (CAS) 4-Cyclohexyl-2-butanone
8	19.817	0.75	(1R*,6S*,10R*)-5,5-dimethyl-11,12-dioxatricyclo[8.2.1.0(1,6)]tridecan-10-ol
9	20.009	0.66	Hexadecane (CAS) n-Hexadecane
10	20.337	1.04	Docosanoic acid (CAS) Behenic acid
11	20.713	0.87	Tricosane (CAS) n-Tricosane
12	20.941	1.28	3-Hexadecene, (Z)- (CAS)
13	21.541	2.79	9-octadecenoic acid (Z)- (CAS) Oleic acid
14	21.867	0.47	2-undecanone, 6,10-dimethyl- (CAS) 6,10-dimethylundecan-2-one
15	22.067	2.35	Tetratetracontane (CAS) n-Tetratetracontane
16	23.015	4.98	Oxacycloheptadec-8-en-2-one (CAS) Ambrettolide
17	23.446	0.88	Pentatriacontane (CAS) n-Pentatriacontane
18	23.667	0.59	Megastigma-3,7(Z),9-triene
19	24.197	1.34	Pentatriacontane (CAS) n-Pentatriacontane
20	24.621	1.55	Oxacycloheptadec-8-en-2-one (CAS) Ambrettolide
21	25.026	1.16	Octadecane, 1-chloro- (CAS) 1-chlorooctadecane
22	25.974	0.40	Pentatriacontane (CAS) n-Pentatriacontane
23	26.891	0.69	Cyclododecanone (CAS) Cyclododecanon
24	27.067	0.37	Hexatriacontane (CAS) n-Hexatriacontane
25	27.973	0.60	1,2-Propanediol, 3-(Phenylmethoxy)-, Diacetate
26	28.388	0.52	Pentatriacontane (CAS) n-Pentatriacontane
27	29.667	1.22	Tetrapentacontane, 1,54-dibromo-
28	29.966	1.79	Tetratetracontane (CAS) n-Tetratetracontane
29	31.909	1.39	Pentatriacontane (CAS) n-Pentatriacontane
30	32.567	1.98	1-Hentetracontanol (CAS) N-Hentetracontanol-1
31	32.790	0.82	6-O-acetyl-7-desoxy-1,2:3,4:8,9:11,12-tetra-O-isopropyliden-7-nitro-.beta.-D-
32	33.117	1.05	Methyl Commate E

Table 3

Volatile organic compounds of sediment from Jada Bahrin River of Bangka Regency, Bangka Island, Indonesia (continuation)

Peak	*Retention time (min)*	*Concentration (%)*	*Name*
33	33.688	3.97	Nonacosanol (CAS)
34	34.060	1.81	Hexacosane, 9-octyl- (CAS) 9-n-Octylhexacosane
35	34.303	1.11	Pentatriacontane (CAS) n-Pentatriacontane
36	34.920	2.67	9,19-Cyclolanost-24-en-3-ol, Acetate
37	35.438	0.65	2-Pentadecanone, 6,10,14-trimethyl- (CAS) 6,10,14-Trimethyl-2-pentadecano
38	36.269	5.36	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy)trimethyl- (CAS) Cycl
39	36.717	0.58	1H-Benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-,
40	36.999	3.43	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy)trimethyl- (CAS) Cycl
41	37.474	1.18	Cycloeucalenol
42	37.817	1.48	Nonacosanol (CAS)
43	38.368	0.70	Silane, (9,19-cyclo-9.beta.-lanost-24-en-3.beta.-yloxy) trimethyl- (CAS) Cycl
44	38.590	0.79	Androst-5-en-3-ol, 4,4-dimethyl-, (3.beta.)- (CAS)
45	39.044	1.50	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
46	39.550	1.20	Cycloeucalenol
47	40.053	1.78	Androst-5-en-3-ol, Trifluoroacetate, (3.beta.)- (CAS)
48	40.639	2.68	13,27-Cycloursan-3-ol, Acetate, (3.Beta.,13.Beta.,14.Beta.)-
49	40.942	0.97	Tetracosane, 11-decyl- (CAS) 11-n-Decyltetracosane
50	41.694	6.36	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
51	42.132	3.08	1-bromo-3,7,11-trimethyl-dodeca-2,6,10-triene
52	42.629	3.31	4,4,6A,6B,8A,11,11,14B-octamethyl-1,4,4A,5,6,6A,6B,7,8,8A,9,10,11,12,
53	43.051	1.01	Norolean-12-ene
54	43.841	0.67	4,4,6A,6B,8A,11,11,14B-octamethyl-1,4,4A,5,6,6A,6B,7,8,8A,9,10,11,12,
55	44.417	0.57	9,19-cyclolanost-24-en-3-ol, Acetate
56	44.867	5.70	9,19-cyclolanost-24-en-3-ol, (3.beta.)- (CAS) Cycloartenol
57	45.517	0.68	Pentatriacontane (CAS) n-Pentatriacontane
58	45.828	2.30	6-isopropenyl-4,8A-dimethyl-3,5,6,7,8,8A-Hexahydro-1H-Naphth
59	46.399	1.22	9,19-cyclolanost-24-en-3-ol, (3.beta.)- (CAS) Cycloartenol
60	47.407	3.86	14-.Beta.-H-Pregna

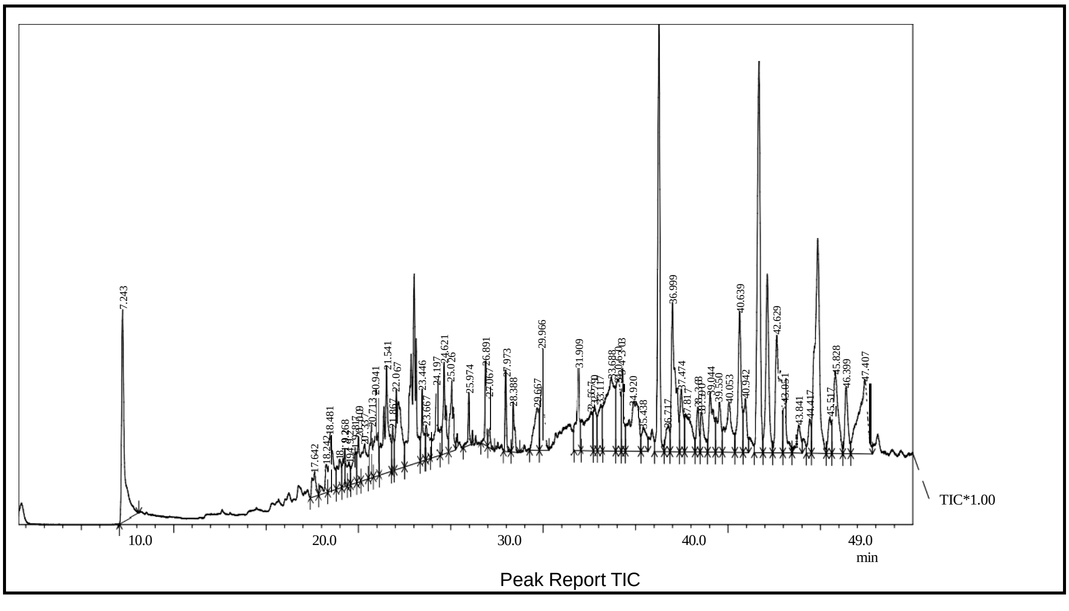

Figure 6. Total chromatogram of sediment from Jada Bahrin River of Bangka Regency.

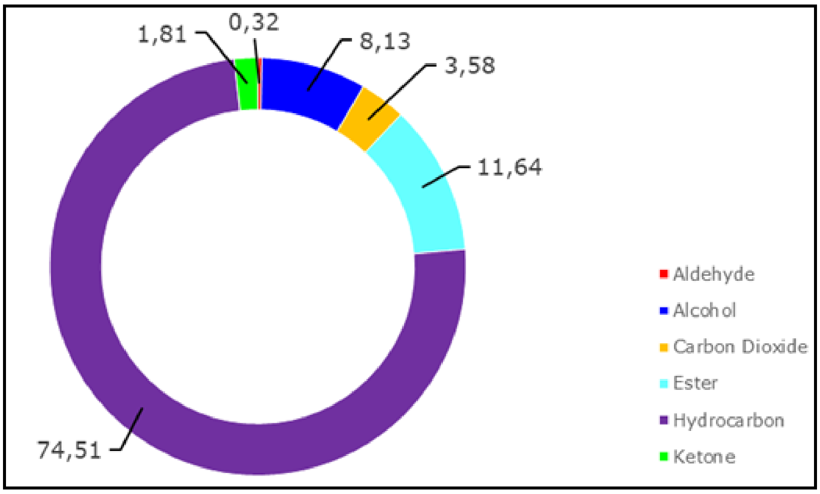

Figure 7. Total volatile compound groups of sediment from Jada Bahrin River.

Benzene accumulation has been observed in *Gafrarium divaricatum*, with concentration between 4.35 and 8.70 mg L^{-1}. Chronic exposure of clams to benzene resulted in loss of bubbling epithelium, separation and necrosis of epithelial cells, reduction in cytoplasm volume and density, fusion of cell membranes, disruption of the inner lining of tubules, and nuclei forming darkly stained areas at basal part of the cells (Agwuocha et al 2011). The presence of benzene in the environment at a concentration of 5.69 μL L^{-1} also affects the physiological processes of mussels, *Perna perna*, reducing oxygen consumption and ammonia excretion (Jorge et al 2007). Furthermore, aromatic hydrocarbon pollutants such as benzene, toluene, and xylene (BTX) contribute to damaging DNA in the bivalve *Corbicula fluminea* (Fedato et al 2010). In this research, we did not obtain benzene contaminated kepah meat in Jada Bahrin River. However, compounds that contain benzene were found in the sediment, so the potential contamination with benzene and its derivates should be considered in future studies.

Overall, this study showed that *P. erosa* can be used as a bioindicator of organic pollutants such as volatile organic compounds. VOCs found in the meat of kepah represented accumulated pollutants from the habitat (Nuryanto & Sastranegara 2013). In this study, we found VOCs containing benzene in the sediment, where benzene can be persistent (Jenneskens et al 2011). Furthermore, we must monitor the presence of benzene that accumulated in kepah. The potential of toxicity for human health is important, because it can produce carcinogenic effects, acute and chronic diseases, nervous system diseases, reproductive and developmental problems, immune system issues, respiratory problems, and hematological diseases (Falzone et al 2016; Dettenrieder et al 2020).

Conclusions. We have confirmed Pyr-GC/MS as an applicable instrument for determining volatile organic compounds (VOCs) in kepah meat, water and sediment. Hydrocarbons were the most abundant compound in kepah meat, water, and sediment, collected from Jada Bahrin River, Bangka Regency, Bangka Island, Indonesia.

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Conflict of Interest. The authors declare that there is no conflict of interest.

References

Agwuocha S., Kulkarni B. G., Pandey A. K., 2011 Histopathological alterations in hepatopancreas of *Gafrarium divaricatum* exposed to xylene, benzene and gear oil-WSF. Journal of Environmental Biology 32(1):35-38.

Argente F. A. T., 2016 Bivalve superpower: the global invasion of corbiculid clams. Annual Research & Review in Biology 10(3):1-10.

Batubara R., Hanum T. I., Affandi O, 2021 GC-MS analysis of young and mature wild agarwood leaves (*Aquilaria malaccensis* Lamk) and its antioxidant potential. IOP Conference Series: Earth and Environmental Science 912:012038.

Biona M. A., Marte C. R., Pasadilla A. L. G., Araneta, B. Y. G., 2017 Estimation of the edible wet tissue weight of the mangrove clam *Polymesoda erosa* harvested from the wild. PEERS Inc. Multidisciplinary Research Journal 1(1):1-9.

Bouzid N., Anquetil C., Dris R., Gasperi J., Tassin B., Derenne S., 2022 Quantification of microplastics by pyrolysis coupled with gas chromatography and mass spectrometry in sediments: Challenges and implications. Microplastics 1(2):229-239.

Bravo-Linares C. M., Mudge S. M., Loyola-Sepulveda R. H., 2010 Production of volatile organic compounds (VOCs) by temperate macroalgae: The use of Solid Phase Microextraction (SPME) coupled to GC-MS as method of analysis. Journal of the Chilean Chemical Society 55(2):227-232.

Cheng S., Zhang J., Wang Y., Zhang D., Teng G., Chang-Chien G. P., Qianli H., Zhang Y. B., Yan P., 2019 Global research trends in health effects of volatile organic compounds during the last 16 years: a bibliometric analysis. Aerosol and Air Quality Research 19(8):1834-1843.

Clemente S., Ingole B., 2011 Recruitment of mud clam *Polymesoda erosa* (Solander, 1876) in a mangrove habitat of Chorao Island, Goa. Brazilian Journal of Oceanography 59(2):153-162.

Conte S., Lagacé F., Netchiporouk E., Sasseville D., Litvinov I. V., 2021 Benzene, a known human carcinogen, detected in suncare products. Journal of Cutaneous Medicine and Surgery 25(6):650-651.

David E., Niculescu V. C., 2021 Volatile organic compounds (VOCs) as environmental pollutants: occurrence and mitigation using nanomaterials. International Journal of Environmental Research and Public Health 18(24):13147.

Dettenrieder C., Türkmen D., Mattsson A., Österlund L., Karlsson M., Mizaikoff B., 2020 Determination of volatile organic compounds in water by attenuated total reflection infrared spectroscopy and diamond-like carbon coated silicon wafers. Chemosensors 8(3):75.

Ding J., Sun C., He C., Li J., Ju P., Li F., 2021 Microplastics in four bivalve species and basis for using bivalves as bioindicators of microplastic pollution. Science of The Total Environment 782:146830.

Dini J. W., 2008 Volatile organic compounds in foods and beverages. Plating and Surface Finishing 95(5):14-15.

Falzone L., Marconi A., Loreto C., Franco S., Spandidos D. A., Libra M., 2016 Occupational exposure to carcinogens: Benzene, pesticides and fibers. Molecular Medicine Reports 14(5):4467-4474.

Fedato R. P., Simonato J. D., Martinez C. B. R., Sofia S. H., 2010 Genetic damage in the bivalve mollusk *Corbicula fluminea* induced by the water-soluble fraction of gasoline. Mutation Research/Genetic Toxicology and Environmental Mutagenesis 700(1-2):80-85.

Genovese A., Marrazzo A., De Luca L., Romano R., Manzo N., Masucci F., Di Francia A., Sacchi R., 2019 Volatile organic compound and fatty acid profile of milk from cows and buffaloes fed mycorrhizal or nonmycorrhizal ensiled forage. Molecules 24(8):1616.

Hadi Y. S., Nawawi D. S., Abdillah I. B., Pari G., Pari R., 2021 Evaluation of discoloration and subterranean termite resistance of four furfurylated tropical wood species after one-year outdoor exposure. Forests 12(7):900.

Hamli H., Rahim A. A., Idris M. H., Kamal A. H. M., King W. S., 2015 Morphometric variation among three local mangrove clam species of Corbiculidae. Songklanakarin Journal of Science and Technology 37(1):15-20.

Jenneskens L. W., Havenith R. W., Soncini A., Fowler P. W., 2011 Aromaticity of strongly bent benzene rings: persistence of a diatropic ring current and its shielding cone in [5] paracyclophane. Physical Chemistry Chemical Physics 13(37):16861-16866.

Jorge R. A. D. L. V. C., Lemos D., Moreira G. S., 2007 Effect of zinc and benzene on respiration and excretion of mussel larvae (*Perna perna*) (Linnaeus, 1758) (Mollusca; Bivalvia). Brazilian Journal of Biology 67(1):111-115.

Juang D. E., Yuan C. S., Hsueh S. C., Chiou L. J., 2009 Distribution of volatile organic compounds around a polluted river. International Journal of Environmental Science & Technology 6(1):91-104.

Latif M. T., Mei C. S., Hanif N. M., Srithawirat T., 2012 Levoglucosan as an indicator of biomass burning from selected tropical plants. EnvironmentAsia 5(2):22-27.

Leiwakabessy J., Nanlohy E. E., Lewerissa S., 2019 Fatty acid profile of some fresh and dried molluscs in Central Maluku, Indonesia. AACL Bioflux 12(4):1189-1195.

Meckenstock R. U., Boll M., Mouttaki H., Koelschbach J. S., Tarouco P. C., Weyrauch P., Dong X., Himmelberg A. M., 2016 Anaerobic degradation of benzene and polycyclic aromatic hydrocarbons. Microbial Physiology 26(1-3):92-118.

Mendoza D. M., Mula M. G., Baysa R. P., 2019 Spatial density, size, growth and condition index of mangrove clam (*Polymesoda erosa*) in the estuarine portion of Pasak River, Sasmuan, Pampanga, Philippines. International Journal of Fisheries and Aquatic Studies 7(4):258-262.

Montero-Montoya R., López-Vargas R., Arellano-Aguilar O., 2018 Volatile organic compounds in air: sources, distribution, exposure and associated illnesses in children. Annals of Global Health 84(2):225-238.

Mustapha S. H. B., 2020 [Microplastic contamination in mollusc Polymesoda]. Dissertation, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor, 64 p. [In Malay].

Mutić J., Jovanović V., Jacxsens L., Tondeleir J., Ristivojević P., Djurdjić S., Rajković A., Veličković T. Ć., 2021 Chemical content of five molluscan bivalve species collected from South Korea: multivariate study and safety evaluation. Foods 10(11):2690.

Nuryanto A., Sastranegara M. H., 2013 Molecular characterisation of *Polymesoda erosa* (Solander, 1786) inhabit two different habitats. Bionatura-Jurnal Ilmu-ilmu Hayati dan Fisik 15(3):184-189.

Patoni I., Susanto A., Hidayat Y., 2022 Potential of fruit extracts as attractants of female oriental fruit flies. Pakistan Journal of Biological Sciences 25(6):537-548.

Peters C. A., Hendrickson E., Minor E. C., Schreiner K., Halbur J., Bratton S. P., 2018 Pyr-GC/MS analysis of microplastics extracted from the stomach content of benthivore fish from the Texas Gulf Coast. Marine Pollution Bulletin 137:91-95.

Smith M. T., 2010 Advances in understanding benzene health effects and susceptibility. Annual Review of Public Health 31:133-148.

Vinci R. M., Jacxsens L., De Meulenaer B., Deconink E., Matsiko E., Lachat C., de Schaetzen T., Canfyn M., Van Overmeire I., Kolsteren P., van Loco J., 2015 Occurrence of volatile organic compounds in foods from the Belgian market and dietary exposure assessment. Food Control 52:1-8.

Wang Q., Wang C., Hou L., Lv B., Chén W. A. N. G., 2018 Pollution data analysis and characteristics of volatile organic compounds in the environment. E3S Web of Conferences 38:01004, 5 p.

Wang R., Mou H., Lin X., Zhu H., Li B., Wang J., Junaid M., Wang J., 2021 Microplastics in mollusks: research progress, current contamination status, analysis approaches, and future perspectives. Frontiers in Marine Science 1671(8):759919.

Yadav R., Pandey P., 2018 A review on volatile organic compounds (VOCs) as environmental pollutants: fate and distribution. International Journal of Plant and Environment 4(2):14-26.

Yildizhan E., Koyutürk L. C., Akkuş M., Tektemur N. K., Özkorkmaz E. G., Fırat A. Ş. I. R., 2021 Examination of apoptotic changes in aromatic hydrocarbon benzene administered rat testicular tissue with histopathological methods. Middle East Journal of Science 7(1):1-10.

Yusoff A. H., Roslan N. N., Chang C. S., Lazim A. M., Nadzir M. S. M., Oslan S. N. H., Sulaiman A. Z., Ahmed M. F., Mohamed M., Zakaria K. A., Tan R., 2021 Heavy metals in marsh clam (*Polymesoda expansa*) as bioindicators for pollution in

industrial and sand mining area of Kelantan River Basin, Malaysia. Trends in Sciences 18(20):1-10.
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