Development of Student Worksheets Based on Science Literacy for Environmental Pollution Materials

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Abstract: This study aims to develop a Student Worksheet (LKPD) based on scientific literacy on environmental pollution material for grade X students of Senior High School. The research method employs a Research and Development (R&D) approach, utilizing a 3D model, conducted at MAN 1 in Bandung City. The instruments used include interview sheets, validation sheets, readability sheets, student response questionnaires, and student worksheets. The validation results indicate that LKPD falls into the 'valid to very valid' category, with a media expert score of 71.25% and a material expert score of 81.33%. The readability test results were 79% and 85%, respectively, and the student response was 86.4%. The average value of the limited trial reached 91. It can be concluded that LKPD, based on scientific literacy regarding environmental pollution and materials, is feasible and effective in supporting biology learning through scientific literacy. Biology teachers can apply the practical implications of this study to enhance the effectiveness of learning and serve as a reference in developing LKPD on other topics related to environmental issues.

Abstrak: Penelitian ini bertujuan untuk mengembangkan Lembar Kerja Peserta Didik (LKPD) berbasis literasi sains pada materi pencemaran lingkungan untuk siswa kelas X SMA/MA. Metode penelitian menggunakan pendekatan *Research and Development* (R&D) dengan model 3D yang dilakukan di MAN 1 Kota Bandung. Instrumen yang digunakan meliputi lembar wawancara, lembar validasi, lembar keterbacaan, kuesioner respon siswa, dan lembar kerja peserta. Hasil validasi menunjukkan LKPD berada pada kategori valid hingga sangat valid, dengan skor ahli media sebesar 71,25% dan ahli materi sebesar 81,33%. Uji keterbacaan oleh guru dan siswa masing-masing sebesar 79% dan 85%, serta respons siswa sebesar 86,4%. Nilai rata-rata uji coba terbatas mencapai 91. Maka dapat disimpulkan bahwa LKPD berbasis literasi sains pada materi pencemaran lingkungan layak digunakan dan efektif dalam mendukung pembelajaran biologi berbasis literasi sains. Implikasi praktis dari penelitian ini dapat diterapkan oleh guru Biologi untuk meningkatkan efektivitas pembelajaran, serta dapat menjadi acuan dalam pengembangan LKPD pada topik lain yang berkaitan dengan isu-isu lingkungan hidup.

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A. Introduction

Science literacy is derived from two Latin words: *literatus*, meaning "letters, literate, or educated," and *scientia*, meaning "knowledge" (Aswita et al., 2022). Science literacy is the ability to apply scientific knowledge to identify problems, draw conclusions based on evidence, and make informed decisions about nature and the impact of human activities on it. This ability can be developed through quality science education that integrates the concept of science literacy, enabling students to understand the impact of science in everyday life (Zukmadini et al., 2021).

PISA (*Program for International Student Assessment)* noted that the level of science literacy among Indonesian students is ranked in the bottom 10, indicating that science literacy skills remain low (OECD, 2022). In addition, the results of the Indonesian Madrasah Competency Assessment (AKMI) conducted by the Indonesian Ministry of Religious Affairs show that 51% of madrasah students are at the "basic" level, which falls within the low category in science literacy (Vokasi, 2021). The same issue was also found at MAN 1 Bandung City, where the results of interviews with biology teachers revealed that the science literacy of their students still needs improvement. There are still many students who have not been able to answer AKMI questions correctly, because the average student there does not like to read questions with long wording.

In addition to information related to the level of science literacy at MAN 1 Bandung City, the results of the interview also revealed that there was no Learner Worksheet (LKPD) available for the material on environmental pollution. This condition presents problems that require immediate attention, one of which is researching to generate relevant data for developing Learner Worksheets (LKPD) on environmental pollution materials.

The Learner Worksheet (LKPD) is one of the supporting elements in the learning process, serving to facilitate an understanding of the material through organized activities. As stated by Noer et al (2025), LKPD is an effective learning alternative for students because it enables them to acquire knowledge about the concepts they have learned through systematic learning activities. In addition, design is also important to consider in the preparation of LKPD, as good design can support the achievement of learning objectives and encourage students to take an active role in their learning. This is in line with Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 87 of 2013, which states that LKPD is a teaching material that must be developed, especially in the context of education (Nasir, 2015).

One of the class X biology materials that students need to understand is environmental pollution, which is included in the submaterial of the environmental change chapter. This material requires effective teaching materials and learning methods to develop students' science literacy skills. Environmental pollution is a change in the environment caused by human activities, such as the number of organisms, radiation levels, and excessive energy use patterns, that decrease the quality of the environment and impair its ability to function as it should (Uki & Bire, 2021). According to Sompotan & Sinaga (2022), environmental pollution can be categorized into three types, namely soil pollution, air pollution, and water pollution.

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Some previous research that supports this study, namely the first research conducted by Huryah et al (2017) showed that the results of science literacy of grade X high school students in Padang City had a low level of biological science literacy, as evidenced by the average score of students' science competence of 48.51%, content 48.12%, and context 46.82%. The second study, conducted by Benhadj et al (2023), showed that science literacy-based LKPD on environmental pollution materials was valid, with an average material validity of 95.3%, graphical validity of 97.6%, language validity of 97.9%, and teacher response of 96%. The third research, conducted by Abdillah et al (2021), shows that observation-based LKPD is content-worthy for testing in learning, as evidenced by the CVR (*Content Validity Ratio*) and CVI (*Content Validity Index*) values of 1, which meet the minimum value for five validators.

Based on previous research, the development of science literacy-based LKPD on environmental pollution material has never been done at MAN 1 Bandung City. Therefore, this study aims to develop science literacy-based LKPD as teaching materials that support the learning process on environmental pollution materials. Specifically, the objectives of this study were to identify the needs of students and teachers for LKPD, design and develop LKPD according to the characteristics of students, assess the quality of LKPD through expert validation and educational practitioners, test the readability and response of students, and analyze the potential of LKPD in improving science literacy. Based on these objectives, the problem formulation in this study is how to develop science literacy-based LKPD on environmental pollution materials.

B. Method

This research employs a combined approach, namely a qualitative and quantitative approach, with a *Research and Development* (R&D) design, to produce interactive learning media (Trianto, 2004). The development procedure refers to Thiagarajan (1974) 3D model, which includes the *Define*, *Design*, and *Development* stages. Due to time and cost constraints, the research was limited to the *Development* stage only. This research was conducted at MAN 1 Bandung City, with research subjects consisting of 15 students from the X.E-11 class.

The research procedure consists of three main stages. The *define* stage involves analyzing the environmental pollution curriculum (Merdeka Curriculum), examining student perspectives, science literacy, and the availability of teaching materials through interviews with biology teachers. The *design* stage includes determining product design, collecting references, preparing drafts, and finalizing LKPD. The *development* stage includes expert validation (media and material expert lecturers), readability testing by teachers and 15 Grade X students, and evaluation of student responses to measure the product's effectiveness and practicality.

Data collection techniques were employed through unstructured interviews with biology teachers for preliminary studies, validation by material and media experts, readability tests, and measurement of student responses. The instruments used include interview sheets, validation sheets based on BSNP (2014) criteria to test the feasibility of teaching material products (Gunawan et al., 2024), readability sheets for biology teachers and students, student

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response questionnaires adapted from Ridwan & Sunarto (2019), and student worksheets for limited trials of products.

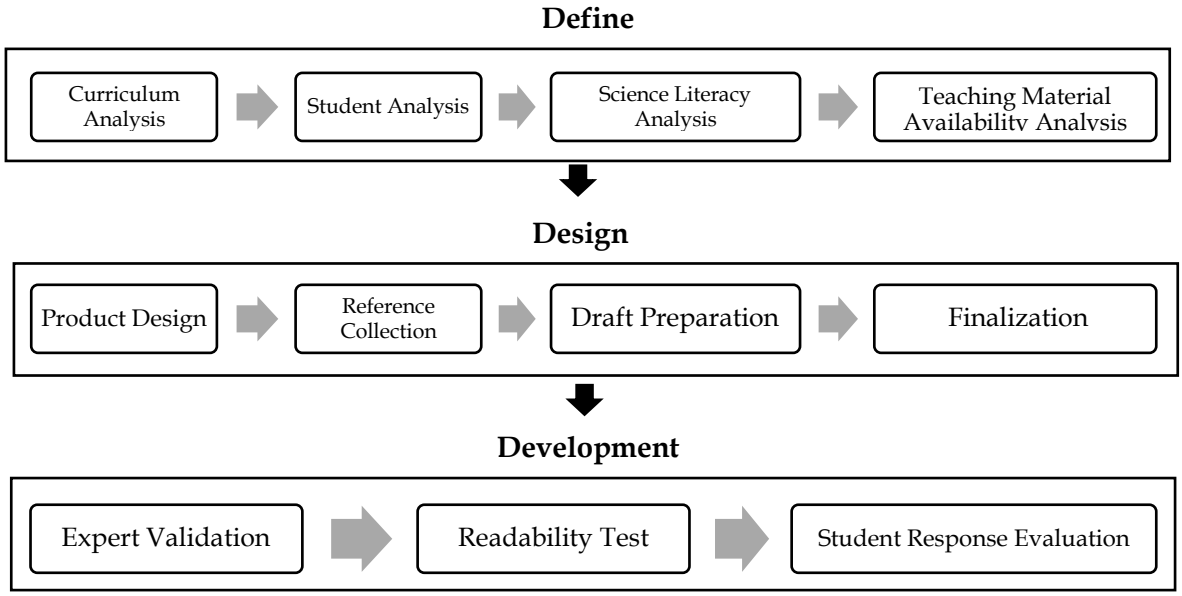

Figure 1. 3D Model Development Flow

Data analysis techniques in the validation test, readability test, and student response test used a five-level Likert scale, referring to the score criteria developed by Riduwan & Sunarto (2019). The assessment score consists of: 5 for the Very Good (SB) category, 4 for the Good (B) category, 3 for the Fair (C) category, 2 for the Less Good (KB) category, and 1 for the Very Poor (SKB) category. The data was analyzed using the percentage formula (number of scores obtained / maximum score × 100%) and then interpreted according to the criteria of each aspect. Expert validation was categorized as highly valid (81-100%), valid (61-80%), moderately valid (41-60%), invalid (21-40%), and highly invalid (0-20%). Readability was categorized as easy to understand (61-100%), suitable to understand (41-61%), and challenging to understand (21-41%). Student responses were categorized as very positive (81-100%), positive (61-80%), moderately positive (41-60%), less favorable (21-40%), and not positive (0-20%). All quantitative calculations were done using Microsoft Excel 2019.

C. Result

This development product was created using the R&D (*Research and Development*) method with a 3D model. The method used aims to produce products based on field tests, which are then revised to make them suitable for use (Rayanto & Sugiyanti, 2020). The following are the stages of development in this study.

The define stage is the initial stage in determining the product to be developed, based on the results of the needs analysis, which aims to reveal the needs and obstacles faced by students during the learning process (Salsabilla et al., 2024). Curriculum analysis shows that MAN 1 Bandung City has implemented the Merdeka Curriculum. However, analysis of

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learning materials reveals difficulties in understanding the topic of environmental pollution due to its abstract nature, including learning achievements (CP), learning objectives (TP), and science literacy competencies (CK) at the SMA/MA level, which are not optimal. The results of the analysis of students' science literacy skills revealed difficulties in understanding the material and solving problems, attributed to the lack of problem-solving-based exercises. Analysis of the availability of teaching materials revealed the unavailability of special teaching materials for environmental pollution, including structured Learner Worksheets (LKPD). As a result, the absence of relevant and engaging teaching materials leads to low interest and motivation among students, which in turn affects their lack of active participation in the learning process.

The ***design*** **stage** begins with preparing the initial draft of the LKPD based on an analysis of teaching material needs and adjusting it to the LKPD criteria using the Canva application. The preparation of the LKPD draft considers the results of interviews with biology teachers related to the grade X Biology curriculum, determining titles that are by the material, determining CP and TP that are aligned with the Merdeka Curriculum, and science literacy CK for SMA / MA level, with A4 paper format equipped with supporting illustrations and engaging learning activities to increase interest in learning and facilitate understanding of the concept of environmental pollution. The structure of the LKPD consists of a cover, an LKPD identity section with a preface and a table of contents, a CP and TP section with indicators of science literacy achievement and instructions for use, a material section, a student activity section consisting of three activities, and a closing section in the form of a glossary, a bibliography, and a compiler's bio which is equipped with an assessment sheet and rubric. The following is the appearance of the LKPD product that has been made.

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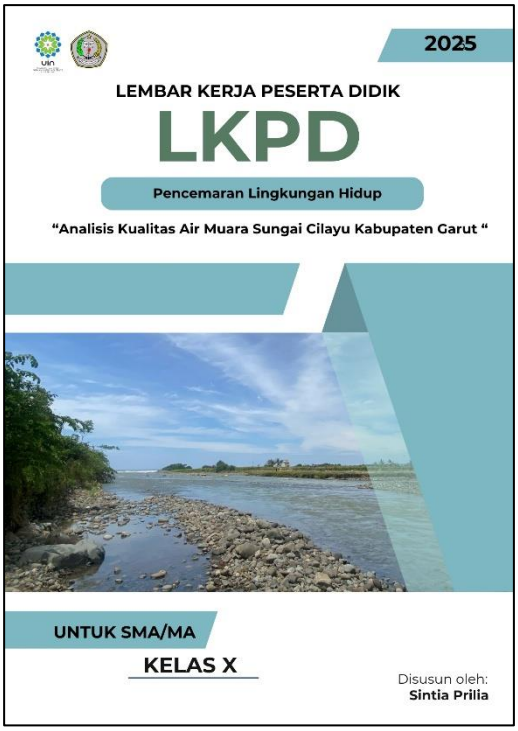

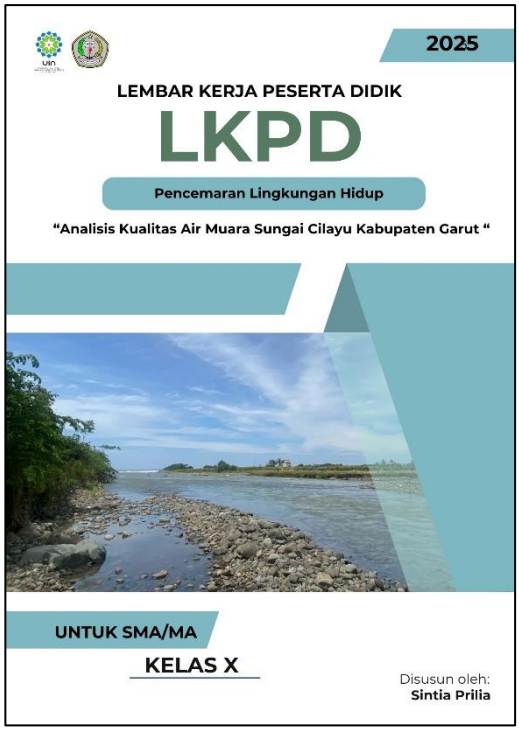

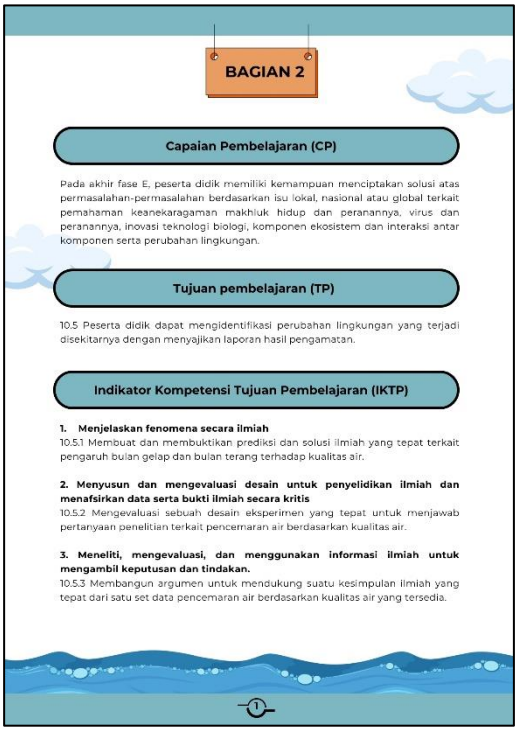

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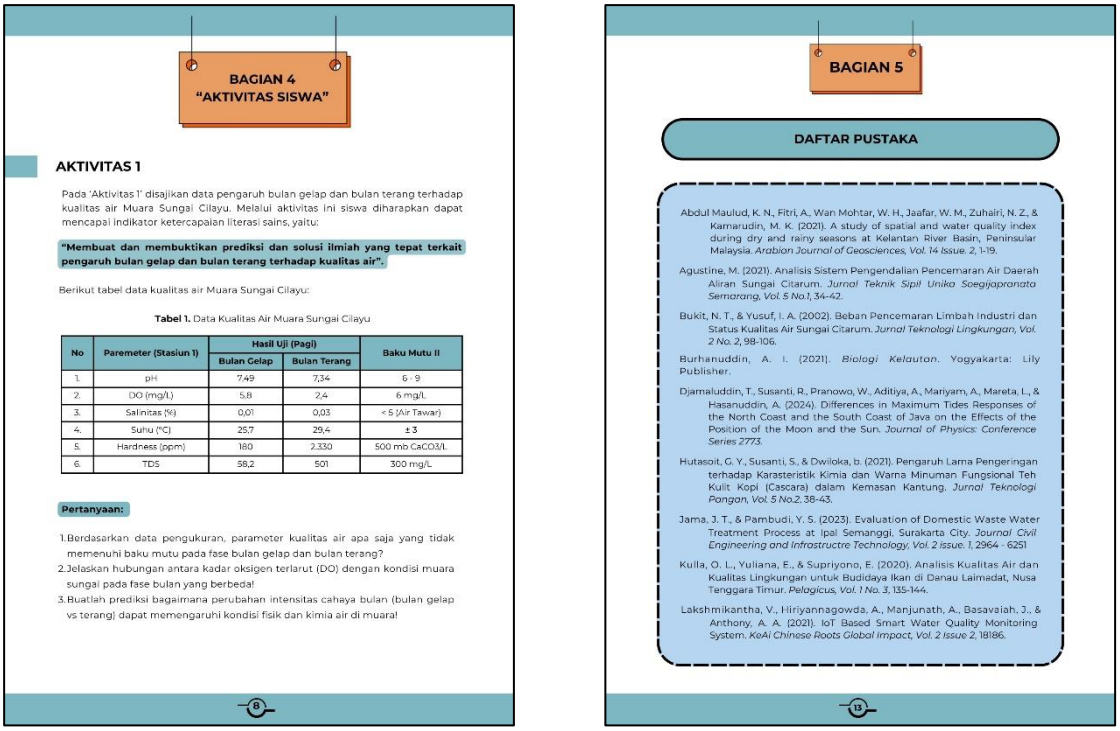

Figure 2. Several Displays of the Results of the Development of LKPD Based on Scientific Literacy on Environmental Pollution Material

Material collection is carried out through the compilation of grade X biology learning materials from Merdeka Curriculum package books, research journals, and internet sources. Then, the preparation and completion of LKPDs compiled using the Canva application were converted into *hardcopy* LKPDs with assessment instruments in the form of LKPD quality evaluation sheets for biology education experts, grade X biology teachers, and responses from grade X SMA/MA students.

The ***development*** stage is the stage of product assessment where the prototype is developed and modified. The LKPD that has been prepared cannot be directly tested on students; instead, it must first be validated by expert validators. The validation in this study includes validation of material experts and media experts. According to Kusuma et al (2020), several aspects need to be considered when conducting validation tests to produce quality teaching material products, including aspects of appearance/technical, language/contextual, and content. Comments and suggestions on the LKPD that have been prepared are obtained during the validation process, then reviewed and revised to produce a higher quality product. Through the input and recommendations given by the validators, the media that has been developed can be further refined. The first validation test was conducted through media expert validation. The results of the media expert validation test are presented in Table 1.

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Table 1. Media Expert Validation Results

No	Assessment Aspect	Percentage (%)	Category
1.	Display and content aspect	73,33%	Valid
2.	Language aspect	70,00%	Valid
3.	Graphic aspect	72,00%	Valid
4.	Characteristic aspect	60,00%	Fairly valid
Total		**71,25%**	**Valid**

Based on the validation results, LKPD media experts obtained a total validity percentage of 71.25% with the category "Valid". This indicates that LKPD is suitable for use in learning, although there are still several aspects that need improvement. The display and content aspects achieved the highest percentage of 73.33% in the valid category, indicating that the visual design and content of the LKPD material were effective and aligned with learning needs. The graphic aspect obtained 72.00% (valid), indicating that the use of images, graphics, and other visual elements is appropriate and supports student understanding. Meanwhile, the linguistic aspect reached 70.00% (valid), indicating that the language used in the LKPD is communicative and in line with the students' ability level. However, the characteristics aspect obtained the lowest percentage of 60.00% with the category "Quite valid", indicating that the specific characteristics of the LKPD still need to be improved to better suit the needs of students.

Products that have been validated are then improved based on suggestions and input from validators to develop these LKPDs, making them better suited for use in class learning. Media expert validators have given the following suggestions and input:

1) At the beginning of the worksheet, the validator suggested adding the Learner Worksheet Identity after the Student Identity page (Figure 3).
2) In the material section, the validator provides input to add instructions regarding the material to be discussed in the LKPD (Figure 4a before revision & 4b after revision).
3) In the question section of the Student Activity, the validator suggested adding a fill-in box so that students can directly write their answers on the LKPD (Figure 5a before revision and 5b after revision).
4) Finally, at the end of the LKPD, the validator suggested adding a compiler's bio section after the bibliography (Figure 6).

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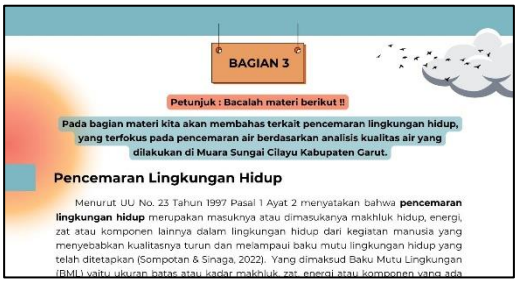
IDENTITAS LEMBAR KERJA PESERTA DIDIK

Judul	:	Lembar Kerja Peserta Didik (LKPD) Berbasis Literasi Sains pada Materi Pencemaran Lingungan Hidup Berrdasarkan Analisis Kualitas Air Muara Sungai Cilayu Kabupaten Garut
Penyusun	:	Sintia Prilia
Keterangan LKPD	:	Lembar Kerja Peserta Didik (LKPD) Berbasis Liresai Sains pada Materi Pencemaran Lingungan ini merupakan salah satu komponen pendukung pembelajaran yang berisi materi data penelitian, dan kegiatan-kegiatan pembelajaran yang dapat membantu peserta didik dalam memahami materi pembelajaran melalui kegiatan pembelajaran yang di dukung berdasarkan fakta lapangan. Selain itu, peserta didik dapat secara mandiri melaksanakan tugas-tugas dan latihan sesuai dengan isi lembar kerja ini.
Pembimbing	:	1. Dr. Epa Paujiah, M.Si. 2. Mar'atus Solikha, M.Sc.
Validator	:	1. Ahli Materi : Dr. Tri Cahyanto, S.Pd., M.Si. 2. Ahli Media : Asrianty Mas'ud, M.Pd.
Ukuran LKPD	:	A4 (21 cm x 29.7 cm)
Asal Institusi	:	Universitas Islam Negeri Sunan Gunung Djati Bandung
Tahun Penyusunan	:	2025

Figure 3. Student Worksheet Identity



BAGIAN 3

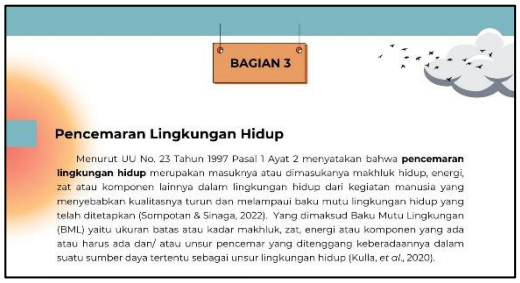
Petunjuk : Bacalah materi berikut !!

Pada bagian materi kita akan membahas terkait pencemaran lingkungan hidup, yang terfokus pada pencemaran air berdasarkan analisis kualitas air yang dilakukan di Muara Sungai Cilayu Kabupaten Garut.

Pencemaran Lingkungan Hidup

Menurut UU No. 23 Tahun 1997 Pasal 1 Ayat 2 menyatakan bahwa **pencemaran lingkungan hidup** merupakan masuknya atau dimasukanya makhluk hidup, energi, zat atau komponen lainnya dalam lingkungan hidup dari kegiatan manusia yang menyebabkan kualitasnya turun dan melampaui baku mutu lingkungan hidup yang telah ditetapkan (Sompotan & Sinaga, 2022). Yang dimaksud Baku Mutu Lingkungan (BML) yaitu ukuran batas atau kadar makhluk, zat, energi atau komponen yang ada

Figure 4a. Before Revision



BAGIAN 3

Pencemaran Lingkungan Hidup

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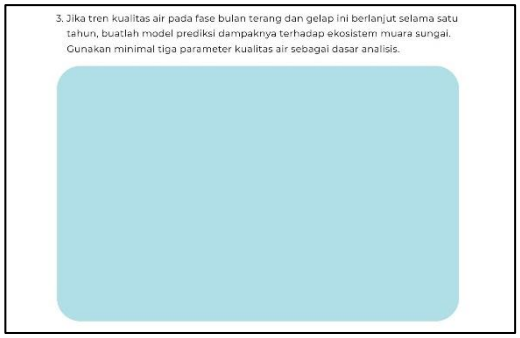
Figure 4b. After Revision

Gambar 9. Grafik Data Kualitas Air Muara Sungai Cilayu

Pertanyaan:

1. Berdasarkan data di atas, parameter apa saja yang tidak memenuhi baku mutu? Jelaskanlah penyebabnya!
2. Rumuskanlah suatu hipotesis tentang hubungan antara kadar oksigen terlarut (DO) dengan kondisi muara sungai pada fase bulan yang berbeda, lalu buktikan hipotesis tersebut menggunakan data yang tersedia!
3. Jika tren kualitas air pada fase bulan terang dan gelap ini berlanjut selama satu tahun, buatlah model prediksi dampaknya terhadap ekosistem muara sungai. Gunakan minimal tiga parameter kualitas air sebagai dasar analisis.

Figure 5a. Before Revision



3. Jika tren kualitas air pada fase bulan terang dan gelap ini berlanjut selama satu tahun, buatlah model prediksi dampaknya terhadap ekosistem muara sungai. Gunakan minimal tiga parameter kualitas air sebagai dasar analisis.

Figure 5b. After Revision

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BIODATA PENYUSUN

Penyusun lahir di Kab. Bandung pada tanggal 17 Juli 2003 sebagai anak pertama dari dua bersaudara. Lahir dari pasangan Bapak bernama "Mista Ardiansya" dan Ibu bernama "Epi Eliani". Riwayat pendidikan formal yang pernah di tempuh:

- SDN Leuwidulang tahun 2009
- SMPN 3 Baleendah tahun 2015
- SMA BPPI Baleendah tahun 2018

Penyusun merupakan mahasiswa semester 8 di Prodi Pendidikan Biologi, Fakultas Tarbiyah dan Keguruan, UIN Sunan Gunung Djati Bandung.

Pada tanggal 30 Desember 2024 penyusun mengikuti sidang proposal skripsi sebagai salah satu syarat dan langkah awal penelitian mengenai analisis kualitas air di Muara Sungai Cilayu. LKPD ini merupakan karya pertama penulis, semoga bisa bermanfaat dalam proses pembelajaran materi Pencemaran Lingkungan. berikut ini adalah Biodata tentang penyusun:

Nama	:	Sintia Prilia
Nama Panggilan	:	Tia
Alamat	:	Kp Leuwidulang RT. 06 RW. 02 Block C No. 1, Desa Rancamulya, Kecamatan Pameungpeuk, Kabupaten Bandung
Agama	:	Islam
No Telp	:	085316018075
Email	:	sintiaprilia15@gmail.com

Figure 6. Compiler's Biodata

The addition of an Identity Sheet to the LKPD is necessary to meet academic eligibility standards and provide product credibility information. The identity serves as formal documentation, demonstrating the authenticity of the work, the responsibility of the authors, and the validity of the content through the name of the validator, while also facilitating reference and citation in academic use (Soenarko et al., 2022). The second suggestion is to provide clear instructions regarding the material to be discussed in the LKPD, so that students do not experience confusion in understanding the material's flow. The third suggestion from the validator was to add a form box so that students can directly write answers on the LKPD. According to Haezer et al (2023), this suggestion is crucial for enhancing the effectiveness of learning, as LKPD serves as a means to facilitate and support learning activities, thereby fostering effective interaction between students and teachers. The last suggestion is to add a compiler profile that provides information about the compiler's identity and competence, serving as a form of accountability and credibility for learning products. Furthermore, the validation test by material experts yielded the following table of results:

Table 2. Material Expert Validation Results

No	Assessment Aspect	Percentage (%)	Category
1.	Content quality aspect	68,00%	Valid
2.	Aspects of the accuracy of the material and questions	75,00%	Valid
3.	Aspects of material and question updates	70,00%	Valid
	Total	**81,33%**	**Very valid**

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Based on the results of the material expert validation presented in Table 2, the developed LKPD achieved a total validity percentage of 81.33%, categorized as "Very Valid." This indicates that the LKPD has excellent material quality and is suitable for educational purposes. The accuracy aspect of the material and questions obtained the highest percentage of 75.00% (valid), indicating that the environmental pollution material presented and the questions developed were aligned with the learning indicators and the students' ability level. The aspect of currency of materials and questions reached a value of 70.00% (valid), indicating that the LKPD content utilizes the latest information and examples related to environmental pollution that are relevant to current conditions. Meanwhile, the content quality aspect obtained a result of 68.00% (valid), indicating that the structure of the material, the depth of the discussion, and the suitability of science literacy are good but can still be improved to achieve more optimal quality.

Products that have been validated are then improved based on suggestions and input from validators. The following are the suggestions and inputs:

1) Image quality needs to be improved, accompanied by informative captions (Figures 7a before revision and 7b after revision).
2) In the Water Pollution material section, the validator suggested adding current environmental issues relevant to students (Figure 8a before revision and 8b after revision).
3) It is necessary to add visual data representation in the form of tables to support analysis (Figure 9a before revision & 9b after revision).
4) In the question section, the validator suggested adding HOTS questions (Figure 10a before revision & 10b after revision).
5) A glossary should be provided to facilitate students' understanding of the concepts used (Figure 11).

Figure 7a. Before Revision

Figure 7b. After Revision

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Figure 8a. Before Revision

Figure 8b. After Revision

Figure 9a. Before Revision

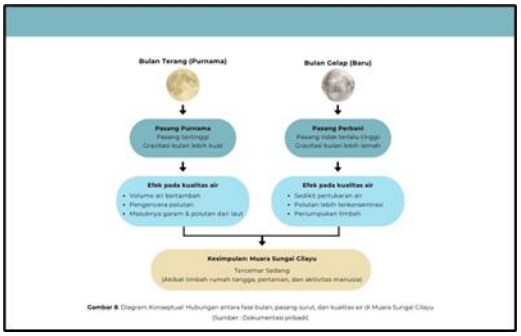

Figure 9b. After Revision

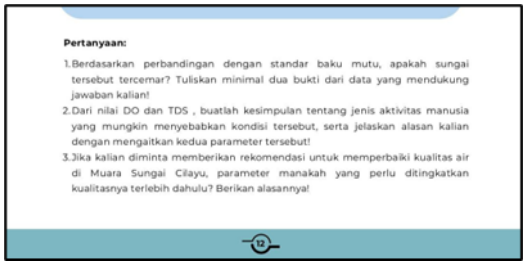

Figure 10a. Before Revision

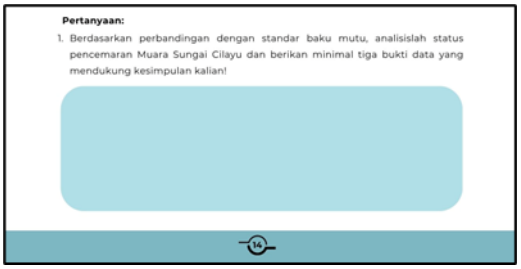

Figure 10b. After Revision

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BAGIAN 5

GLOSARIUM

Baku Mutu Lingkungan : Ukuran batas atau kadar makhluk hidup, zat, energi, atau komponen yang ada atau harus ada dan/atau unsur pencemar yang ditenggang keberadaannya dalam suatu sumber daya tertentu sebagai unsur lingkungan hidup.

BOD (*Biochemical Oxygen Demand*) : Ukuran kandungan oksigen terlarut yang diperlukan oleh mikroorganisme untuk menguraikan bahan organik di dalam air.

Bulan Gelap : Fase bulan baru ketika bulan tidak terlihat dari bumi karena posisinya berada di antara bumi dan matahari.

Bulan Terang : Fase bulan purnama ketika seluruh permukaan bulan yang menghadap ke bumi terlihat terang karena disinari matahari.

COD (*Chemical Oxygen Demand*) : Ukuran kandungan oksigen yang diperlukan agar bahan buangan di dalam air dapat teroksidasi melalui reaksi kimia.

DO (*Dissolved Oxygen*) : Ukuran kandungan oksigen terlarut dalam air, merupakan indikator penting kualitas air dan kemampuannya mendukung kehidupan akuatik.

Estuari : Wilayah perairan yang semi tertutup di mana air tawar dari sungai bertemu dengan air asin dari laut atau samudra.

***Hardness* (Kesadahan)** : Kandungan mineral terlarut dalam air, terutama ion kalsium (Ca^{2+}) dan magnesium (Mg^{2+}), yang dapat mengurangi efektivitas sabun dan membentuk kerak.

Indikator Alami : Bahan yang diperoleh dari alam yang dapat digunakan untuk mendeteksi perubahan kimia dalam suatu larutan, seperti air teh yang dapat mendeteksi keberadaan zat besi.

Konduktivitas : Kemampuan air untuk menghantarkan arus listrik, yang berhubungan langsung dengan jumlah padatan terlarut dalam air.

Figure 11. Glossary

Improving the quality of images and adding informative captions is one of the key strategies in developing effective teaching materials, as the use of high-quality images can enhance visual appeal and help students grasp concepts more deeply. This aligns with Kosasih (2021) opinion, which emphasizes that the visual components in LKPD must be presented with high quality and accompanied by clear descriptions. In addition, integrating current environmental issues relevant to students' lives, especially those related to water pollution, is considered important to increase the connection between the material and students' reality. Research by Handiyati et al (2023) demonstrated that incorporating local environmental issues into learning can enhance learning motivation and strengthen conceptual understanding. The addition of visual data representations, such as tables, also supports students in organizing information and analyzing data systematically, as explained by Özdem et al (2017), who note that exposure to various forms of data representation can strengthen students' science literacy. Furthermore, the insertion of HOTS (Higher Order Thinking Skills) oriented questions encourages students to think critically, analytically, and creatively, according to the findings of Udayani et al (2024), who stated that HOTS questions are effective in improving higher-order thinking skills. Finally, the provision of a glossary also needs to be considered, as according to Larasati (2023), glossaries play a crucial role in helping students understand the technical terms used in teaching materials.

After the LKPD was deemed feasible by expert validators, the next step was to conduct a readability test involving biology teachers and 15 students from class X. The following is presented first: the results of readability by the Xth-grade biology teacher in Table 3.

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Table 3. Results of Readability Test by Biology Teacher

No	Assessment Aspect	Percentage (%)	Category
1.	Content quality aspect	84,00%	Easy to understand
2.	Aspects of the accuracy of the material and questions	80,00%	Easy to understand
3.	Aspects of material and question updates	76.67%	Easy to understand
4.	Display and content aspects	76,67%	Easy to understand
5.	Language aspect	75,00%	Easy to understand
6.	Graphics aspect	84,00%	Easy to understand
7.	Characteristic aspect	80,00%	Easy to understand
	Total	**79,00%**	**Easy to understand**

Based on the results of the readability test conducted by biology teachers, it is evident that all aspects of the assessment fall into the "easy to understand" category, with a total percentage of 79.00%. This finding indicates that the LKPD is well-prepared, featuring clear language, an attractive appearance, and accurate and relevant content, which makes it easier for teachers to understand and utilize these teaching materials in learning activities. However, there is input to reduce the number of questions so that there are not too many and are more adapted to the level of thinking ability of grade X students. The results of the revision are shown in Figure 12a before the revision and 12b after the revision.

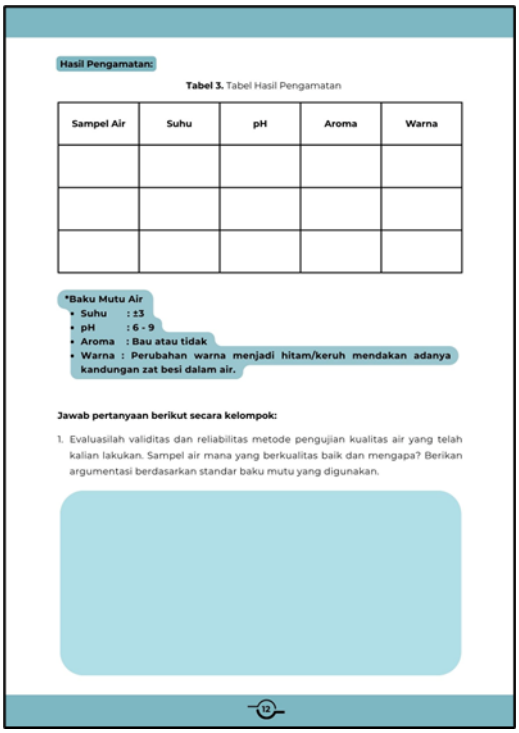

Figure 12a. Before Revision

Figure 12b. Before Revision

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Furthermore, the readability test conducted by grade X students aims to assess the extent to which the LKPD, which has been developed, is easy to understand and helps students practice their science literacy skills. The complete results of the readability test by grade X students are presented in Table 4.

Table 4. Highest and Lowest Readability Test Results by Grade X Students

No	Category	Percentage	Category
1.	Highest Score	100%	Easy to understand
2.	Lowest Score	68,57%	Easy to understand
	Overall average	**85%**	**Easy to understand**

Based on the results of the readability test, the developed LKPD shows an excellent level of readability with an overall average of 85% in the "Easy to understand" category. The highest score reached 100% with the easy-to-understand category, indicating that most of the LKPD content can be understood very well by users. In comparison, the lowest score of 68.57% fell within the easy-to-understand category, indicating that although there are relatively more difficult parts, they are still within the limits that students can comprehend. According to Setyaningsih & Saptono (2025), readability percentages falling within the range of 61% to 100% are categorized as easy to understand. Readability in teaching materials can significantly impact the understanding of the material taught during the learning process, making it a crucial consideration. If the presentation aspect, display aspect, and linguistic aspect are easy to understand, then the LKPD can support the success of the learning process.

Before the LKPD is used in the learning process, a limited trial is conducted to assess the extent to which this science literacy-based student worksheet on environmental pollution material can be understood and utilized in the learning process. According to Marsya & Tamam (2023), the limited trial aims to obtain initial responses from students to the evaluation tools or media that have been developed. A limited trial was conducted involving 15 students from Class X.E-11 MAN 1 in Bandung City to complete the LKPD. The following data on the results of the limited trial are presented in Table 5.

Table 5. Limited Trial Results

No	Group	Score
1.	Group 1	87,5
2.	Group 2	91
3.	Group 3	95
	Overall average	**91**

The results of students' limited trials of LKPD showed excellent results with an overall average score of 91. Group 3 achieved the highest score of 95, followed by Group 2 with a score of 91, and Group 1 with a score of 87.5. The range of scores between 87.5 and 95 shows that all groups were able to complete the LPD well, although there were slight differences in the achievement of the results. The average score indicates that the LKPD developed has been

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effective and can be well understood by grade X students, aligning with their ability level. This finding reinforces that the science literacy-based LKPD is feasible for application in broader learning contexts, as it effectively helps students understand the concept of environmental pollution.

After analyzing the results of the limited trial of the LKPD, the next step is to analyze the students' response questionnaire. This questionnaire was filled out by 15 students who were the same as the participants in the previous readability test. The following are the results of students' responses presented in Table 6.

Table 6. Results of the Highest and Lowest Learner Response by Class X Students

No	Category	Percentage	Category
1.	Highest Score	100%	Very Valid
2.	Lowest Score	68%	Valid
	Overall average	**86,4%**	**Very Valid**

Based on the results of student responses presented in the table, the science literacy-based LKPD on environmental pollution material received a very positive response from Class X students, with an overall average of 86.4% in the "Very Valid" category. The highest score reached 100%, with a very valid category, indicating that most students provided an excellent assessment of the developed LKPD. Meanwhile, the lowest score of 68% was still within the valid category, indicating that although some students gave lower ratings, they were still within acceptable limits. These results confirm that the developed LKPD has met the expectations and needs of students in learning. This aligns with Noormiati et al (2023), who stated that LKPD, with its attractive layout, text, images, and effective use of letters and colors, can increase students' interest and motivation to learn.

D. Discussion

The results of this study indicate that the development of science literacy-based LKPD on environmental pollution material has met the eligibility criteria from the aspects of validity, readability, and students' responses. Validation by media experts scored 71.25% and was categorized as valid, while validation by material experts reached 81.33% and was classified as very valid. This demonstrates that the developed LKPD meets the quality standards of content, accuracy, language, and graphic display about learning needs. This finding aligns with the opinion of Kusuma et al (2020) that content and media validation are crucial steps in ensuring the quality of teaching material products.

The readability of the LKPD was also rated highly by Biology teachers, with a score of 79%, and by students, at 85%, both of which fell into the "easy to understand" category. According to Setyaningsih & Saptono (2025), a high level of readability is crucial in supporting students' understanding of the material and enhancing the effectiveness of the learning process. Input from teachers has been implemented to simplify the number of questions, adjusting to the thinking abilities of grade X students.

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The limited trial involving 15 students resulted in an average score of 91, with a score range of 87.5 to 95. This indicates that the LKPD can not only be well understood by students, but also effectively used in learning activities. Furthermore, the learner response questionnaire showed an average of 86.4% in the very valid category. This supports the opinion of Noormiati et al (2023) that the use of visually appealing learning media can increase students' interest and motivation to learn.

Overall, these findings indicate that the development of science literacy-based LKPDs not only meets the criteria of academic validity but also effectively addresses students' needs in understanding abstract concepts, such as environmental pollution, through contextual and interactive approaches. This research also reinforces the importance of integrating science literacy with activity-based teaching materials to increase students' active participation and conceptual understanding.

E. Implication

This research makes a significant contribution to the development of contextual teaching materials that support the improvement of science literacy at the senior secondary and senior middle school levels. The results of developing LKPD based on science literacy can serve as an alternative learning medium that not only facilitates in-depth understanding of concepts but also encourages active student involvement in the learning process. Biology teachers can apply the practical implications of this research to improve the effectiveness of learning and serve as a reference in developing LKPD on other topics related to environmental issues.

F. Limitations and Suggestions for Further Research

This study has limitations, including the small number of trial subjects, which involved only one class and was conducted at a single school, namely MAN 1 Bandung City. The suggestion that researchers can put forward is the need for further research, specifically application research, on a larger number of students to avoid the limitations of the current study, which involved only 15 students.

G. Conclusion

Based on the results of research and analysis conducted, science literacy-based LKPD on environmental pollution materials for class X SMA/MA students is deemed feasible and effective for use in learning. Validation by material and media experts indicates that the LKPD falls into the categories of valid and very valid. The readability test showed that teachers and students easily understood the LKPD, and student responses showed a very high level of acceptance. This LKPD has been proven to improve concept understanding, learning motivation, and provide a fun and meaningful learning experience. Therefore, this science literacy-based LKPD is recommended for use in learning about environmental pollution materials and further developed for other materials.

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