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ECOLOGICAL LITERACY ENHANCING ADOLESCENT MENTAL HEALTH IN THE DIGITAL ERA

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ABSTRACT

Adolescent mental health has become an increasing concern in the digital era due to excessive exposure to digital media and reduced interaction with natural environments. Ecological literacy has emerged as a potential approach to promoting psychological well-being and encouraging sustainable behaviors among adolescents. This study aimed to analyze the role of ecological literacy in enhancing adolescent mental health through a literature review of ten scientific articles published between 2021 and 2026. The selected studies included systematic reviews, integrative reviews, longitudinal studies, cross-sectional surveys, and experimental studies related to adolescent mental health, environmental health literacy, nature connectedness, and nature-based interventions. The findings indicated that excessive social media use is associated with anxiety, stress, depression, and low self-esteem among adolescents. In contrast, ecological literacy, environmental health literacy, and stronger connections with nature contribute to better emotional regulation, positive affect, life satisfaction, and pro-environmental behaviors. School-based nature interventions also demonstrated positive effects on adolescents' physical, social, and psychological well-being. These findings suggest that ecological literacy has considerable potential as a promotive strategy for strengthening adolescent mental health and resilience in the digital era through the integration of environmental education and meaningful experiences with nature.

Keywords: Ecological Literacy, Adolescent Mental Health, Digital Era, Nature Connectedness, Psychological Well-Being

INTRODUCTION

Adolescence is a critical developmental period characterized by significant biological, cognitive, emotional, and social changes. During this stage, adolescents are highly susceptible to environmental influences that may affect their psychological well-being. In the digital era, rapid technological advancement and extensive use of social media have transformed the way adolescents communicate, express themselves, and access information. Although digital technologies provide various opportunities for learning and social interaction, excessive exposure to social media has been associated with anxiety, depression, stress, sleep disturbances, and reduced self-esteem among adolescents (Daka et al. 2025).

At the same time, urbanization and screen-based lifestyles have reduced adolescents' interactions with natural environments. Ecological literacy refers to the ability to understand ecological systems and develop responsible attitudes and behaviors toward the environment. Previous studies have demonstrated that environmental health literacy and connectedness with nature play important roles in promoting psychological well-being and sustainable behaviors among adolescents (Matos et al. 2025).

Recent evidence also highlights that improving adolescent mental health requires behavioral and psychoeducational interventions in addition to environmental approaches. Health Belief Model (HBM)-based psychoeducation has been shown to significantly improve adolescents' self-awareness, self-efficacy, emotional regulation, and accessibility to mental health services. These findings suggest that strengthening mental health literacy may complement ecological literacy by equipping adolescents with adaptive coping strategies and encouraging early help-seeking behaviors in the digital era (Sembiring et al. 2025).

Stronger connections with nature have been shown to improve positive affect, emotional regulation, and life satisfaction, while emotional connectedness with nature also contributes to pro-environmental behaviors (Dong and Geng 2025). Furthermore, school-based greenspace interventions have been found to enhance physical activity, social interaction, and psychological well-being among children and adolescents (Ly and Vella-Brodrick 2024).

(Yildirim, Willison, and Bentley 2026) proposed an Integrated Nature Connectedness Framework and highlighted the phenomenon of "teenage dip," referring to a decline in adolescents' connectedness with nature during early adolescence. Despite increasing evidence regarding the beneficial effects of nature and environmental education, previous studies have mainly focused on either the negative impact of digital environments or the relationship between nature and well-being separately. Comprehensive evidence concerning the role of ecological literacy in enhancing adolescent mental health in the digital era remains limited However, limited studies have integrated both digital environmental risks and nature-based protective factors in a single ecological literacy framework for adolescent mental health.

Therefore, this literature review aims to analyze existing scientific evidence regarding the role of ecological literacy in enhancing adolescent mental health in the digital era and to identify its potential as a promotive strategy for strengthening adolescents' psychological well-being and resilience.

Contribution to Sustainable Development Goals (SDGs)

This study is aligned with the Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), and SDG 13 (Climate Action). This research supports SDG 3 by addressing adolescent mental health in the digital era and promoting ecological literacy as a protective factor for psychological well-being. It contributes to SDG 4 by emphasizing the role of education in strengthening ecological literacy and mental health literacy among adolescents through school-based learning. In addition, this study supports SDG 13 by encouraging environmental awareness and pro-environmental behavior through ecological literacy and nature connectedness, which contribute to sustainability and climate change awareness.

RESEARCH METHOD

This study employed a narrative literature review design to examine the role of ecological literacy in enhancing adolescent mental health in the digital era. A narrative review was used to synthesize findings from studies with various research designs and to identify key themes and relationships across the literature. Relevant articles were searched through electronic databases and scientific journal platforms, including Google Scholar, Scopus-indexed journals, and other reputable sources, using keywords such as "ecological literacy," "adolescent mental health," "digital era," "environmental health literacy," "nature connectedness," and "nature-based intervention." The inclusion criteria were articles published between 2021 and 2026, full-text English articles, studies focusing on adolescents, and research addressing mental health in relation to digital or environmental factors, including empirical, systematic, integrative, and experimental studies. Exclusion criteria included duplicate articles, non-relevant topics, and opinion papers without clear methodology. A total of 270 articles were initially identified, 35 were screened for eligibility, and 10 articles were selected for final analysis. Data were analyzed using thematic analysis by reviewing objectives, methods, sample characteristics, variables, and key findings, which were then grouped into major themes: digital environment and adolescent mental health, ecological literacy and nature connectedness, and protective and risk factors influencing psychological well-being. A comparative synthesis was conducted to identify patterns and differences across studies to develop an integrated understanding of ecological literacy as a promotive strategy for adolescent mental health in the digital era.

RESEARCH RESULTS

The following is a summary of the ten articles that were selected and reviewed in this study, including the research methods and sample characteristics, variable focus, and the main findings of each study. The synthesized findings provide an overview of the relationship between digital environments, ecological literacy, and adolescent mental health.

No	Author/Year	Title	Method and Samples	Key Findings
1	(Daka et al. 2025)	Social media, psychosocial factors, mental health of adolescents (12-24 years)	Systematic literature review; 10 selected articles from 270 search results (2019-2024)	Excessive social media use is associated with anxiety, depression, and low self-esteem; adolescent girls are more vulnerable to cyberbullying
2	(Matos et al. 2025)	HBSC Survey 2022 Portugal; n = 7,355 adolescents; CFA & multilevel regression	Environmental health literacy (EHL): knowledge, behavior, social norms	Social norms & voluntary participation predict EHL knowledge (25.2% variance); social norms & knowledge predict behavior (42.9% variance); there is a knowledge-behavior gap
3	(Yildirim, Willison, and Bentley 2026)	Integrative review; 56 studies (2014-2024) FRISMA	Conceptual framework of nature connectedness in adolescent	Proposes the Integrated Nature Connectedness Framework (INCF) with 6 core dimensions; identifies the phenomenon of the

				"teenage dip" at ages 11-12
4	(Mueller and Flouri 2023)	Understanding Society longitudinal study; n = 4,217 observations of 10-15 year olds in London	Access to high biodiversity green spaces (SINC) and mental health	No significant associations were found between SINC access and adolescent mental health, self-esteem, or happiness (null results)
5	(Ly and Vella-Brodrick 2024)	PRISMA systematic review; 19 experimental/quasi-experimental studies from 17 articles; children & adolescents 5-19 years	School-based greenspace interventions on mental, physical, and social well-being	Nature exposure in schools increases positive affect, physical activity, and social interaction; gender effects were found (girls benefited more from physical activity), age effects were inconclusive
6	(Maulana et al. 2025)	Mental health education for adolescents in the digital era (community service program)	Qualitative case study; semi-structured interviews with 10 adolescents aged 16-18 years	Teenagers experience concentration problems, negative thoughts/insecurity, and feelings of hopelessness triggered by social media, cyberbullying, and FOMO: some use gaming as a coping strategy
7	(Tasijawa 2025)	Mental health education. Literacy for adolescent mental resilience	Community service; animated IEC; + MHC-SF video questionnaire; 50 students & 6 junior high school teachers	The "good" score category increased from 76% (pre-test) to 94% (post-test); the emotional, social, and psychosocial well-being of the majority was high (70-86%)
8	(Carolina 2026)	The impact of the digital era on adolescent behavior and mental health	Literature review (simple PRISMA); 9 selected articles from 200 search results (2021-2026)	The digital era brings dual impacts: positive (access to information, digital literacy) and negative (anxiety, stress, cyberbullying, juvenile delinquency, erosion of ethics)
9	(Dong and Geng 2025)	Connection with and satisfaction of young people's natural life	Chinese adolescents SEM; 667 Quantitative., aged 13-17 years	Connection with nature is positively associated with life satisfaction through the mediation of

				positive affect and cognitive reappraisal; negative affect decreases life satisfaction.
10	(Anderson and Krettenauer 2021)	Connectedness to nature and pro-environmental behavior	Quantitative; survey across age & living context; 1,251	ECN is the strongest predictor of PEB; ECN declines in early-middle adolescence and then increases in adulthood; ECN mediates the relationship between age and PEB.
11	Banurea et al. (2025)	Quantitative study	Good sleep patterns were positively associated with better mental health, lower stress levels, improved mood, and enhanced cognitive performance among adults.	Supports behavioral factors that complement ecological literacy in improving adolescent mental health and psychological well-being.
12	Munthe et al. (2025)	Qualitative descriptive study	Appropriate care for low birth weight (LBW) infants, including adequate nutrition, developmental stimulation, hygiene, warmth, and regular monitoring, supported optimal child development and emphasized the importance of family-based health education.	Supports the role of health promotion, family education, and community-based interventions in improving health outcomes, which complement ecological literacy strategies.
13	Sembiring et al. (2024)	Quantitative study	Self-awareness and self-efficacy significantly improved adolescents' emotional and mental regulation. The study also proposed a health promotion–based	Supports the integration of psychoeducation, self-awareness, and self-efficacy as complementary strategies for strengthening adolescent mental health alongside ecological literacy.

			educational approach to enhance adolescents' mental health accessibility.	
14	Sembiring et al. (2025)	Community service (pre-test–post-test evaluation)	The implementation of a Self-Help Approach integrated with a telemedicine-based Health Belief Model improved adolescents' knowledge regarding mental health service accessibility. The proportion of participants with good knowledge increased from 12% before the intervention to 68% after the intervention.	Supports community-based psychoeducation and digital health promotion as complementary strategies for improving adolescent mental health.
15	Sinaga et al. (2026)	Quasi-experimental study	PENA (Education and Animation)-based psychoeducation significantly improved adolescents' knowledge and health-related behaviors compared with leaflet-based education. The intervention group achieved higher knowledge scores (p = 0.015) and demonstrated significant behavioral improvement (p = 0.001), with a large intervention effect	Supports the use of innovative digital psychoeducation to strengthen adolescent mental health literacy and promote positive health behaviors alongside ecological literacy interventions.

			(effect size r = 0.58).	

Additional findings from the reviewed studies also demonstrated that adolescent mental health can be strengthened through complementary educational and behavioral interventions. Health Belief Model-based psychoeducation improved adolescents' self-awareness, self-efficacy, emotional regulation, and accessibility to mental health services (Sembiring et al. 2025). Animation-assisted psychoeducation also significantly enhanced adolescents' knowledge and positive health behaviors compared with conventional educational methods (Sinaga et al. 2026).These findings indicate that ecological literacy should be integrated with evidence-based psychoeducational strategies to optimize adolescent mental well-being in the digital era. Telemedicine-supported self-help interventions increased adolescents' knowledge regarding access to mental health services (Sari Br Sembiring et al. 2024). Furthermore, healthy sleep behaviors contributed to better psychological well-being and cognitive performance (Banurea et al., 2025). Family-centered health promotion also emphasized the importance of preventive education and continuous health monitoring in supporting healthy development (Juliana Munthe et al. 2025).

DISCUSSION

Effects of the Digital Environment on Adolescent Mental Health

The reviewed studies consistently show that exposure to digital media, particularly social media, is associated with increased psychological vulnerability among adolescents. Hadiansyah et al. (2025) and Carolina et al. (2025) report that excessive social media use is linked to insecurity, anxiety, depression, sleep disturbances, and reduced self-esteem. These outcomes are largely driven by social comparison processes, fear of missing out (FOMO), cyberbullying, and the need for external validation through online feedback mechanisms.

However, the impact of digital environments is not uniformly negative. When accompanied by adequate mental health literacy and self-regulation skills, digital platforms may provide benefits such as improved access to information and social support. Tasijawa et al. (2025) demonstrate that school-based mental health literacy interventions significantly improve adolescents' psychological well-being, indicating that digital risks can be mitigated through structured educational approaches and supportive environments.

Ecological literacy may be further strengthened through psychoeducational interventions. Health Belief Model (HBM)-based psychoeducation has been reported to improve adolescents' self-awareness, self-efficacy, emotional regulation, and accessibility to mental health services, indicating that behavioral education complements ecological literacy in promoting adolescent mental well-being (Sembiring et al. 2025).

Nature Connectedness as a Protective Factor

In contrast, studies on nature connectedness demonstrate a consistent positive relationship with adolescent well-being. Dong and Geng (2025) show that connection with nature is associated with higher life satisfaction, mediated by positive affect and cognitive reappraisal. Similarly, Anderson and Krettenauer (2021) find that emotional connectedness to nature is a strong predictor of pro-environmental behavior and psychological well-being across developmental stages.

These effects can be explained through stress recovery theory and attention restoration theory, which suggest that natural environments support emotional recovery, reduce cognitive overload, and enhance self-regulation capacities. Importantly, the literature indicates that active engagement with nature is more effective than passive exposure, emphasizing the importance of meaningful interaction rather than mere physical access to green spaces.

Innovative educational strategies also contribute to adolescent mental health promotion. Animation-based psychoeducation and telemedicine-assisted self-help approaches have been shown to improve mental health knowledge, positive health behaviors, and access to mental health services among adolescents (Sinaga et al. 2026).

Comparative Mechanisms Between Digital and Natural Environments

When both environmental domains are compared, a clear divergence in psychological mechanisms emerges. The digital environment tends to activate upward social comparison and external validation dependency, which increase emotional distress. Conversely, natural environments promote internal regulation processes such as cognitive reappraisal, attentional restoration, and emotional stabilization, which enhance psychological resilience.

Despite these contrasting effects, both environments play a significant role in shaping adolescent development. Adolescents are particularly sensitive to external environmental influences due to ongoing identity formation and emotional maturation. Therefore, mental health outcomes are determined not by a single environmental factor, but by the balance between risk-inducing (digital) and restorative (natural) experiences.

In addition, healthy sleep habits and family-based health promotion support psychological well-being by encouraging healthy behaviors and preventive practices. These findings reinforce that ecological literacy should be integrated with healthy lifestyle promotion and community-based interventions to achieve more comprehensive adolescent mental health outcomes (Banurea et al. 2024).

Moderating Factors and Contextual Influences

Across the reviewed studies, gender, developmental stage, and sociocultural context emerge as important moderating factors. Female adolescents tend to exhibit higher vulnerability to digital stressors but may also benefit more from structured interventions. Additionally, adolescence represents a critical developmental period characterized by fluctuations in nature connectedness and increased engagement with digital media, often referred to as a “teenage dip” in environmental connectedness.

Differences in cultural and geographical contexts also influence outcomes, as studies conducted in Indonesia, China, and Canada demonstrate variations in behavioral patterns and psychological responses. This highlights the importance of contextual sensitivity in interpreting and generalizing findings across populations.

Methodological Limitations and Research Implications

The reviewed studies are limited by methodological heterogeneity, including the predominance of cross-sectional and descriptive designs in Indonesian studies and variability in measurement of key constructs such as mental health, digital exposure, and nature connectedness. These limitations restrict causal inference and reduce cross-study comparability. Future research should prioritize longitudinal and experimental designs as well as standardized measurement frameworks to improve the robustness of evidence.

Integrated Implications

Overall, the synthesis suggests that adolescent mental health should be understood through an ecological framework that integrates both risk and protective environmental factors. Effective interventions should not only focus on reducing harmful digital exposure through literacy and self-regulation strategies but also actively promote engagement with natural environments to enhance emotional regulation and psychological resilience. A combined approach implemented within school settings appears particularly promising for comprehensive adolescent mental health promotion. These findings suggest that schools should integrate ecological literacy-based programs into adolescent mental health promotion strategies to support psychological well-being and resilience in the digital era.

CONCLUSION

Based on the synthesis of ten reviewed studies, adolescent mental health in the digital era is shaped by a complex interaction between digital environmental exposure and engagement with natural environments. Excessive and uncontrolled social media use is consistently associated with increased psychological risks, including anxiety, stress, depression, reduced self-esteem, and emotional vulnerability. These effects are primarily driven by social comparison processes, cyberbullying, fear of missing out, and external validation pressures in online environments.

In contrast, ecological literacy, environmental health literacy, and connectedness to nature function as protective factors that contribute to adolescents' psychological well-being. Stronger connections with nature are associated with improved emotional regulation, positive affect, life satisfaction, and pro-environmental behavior. Evidence also indicates that school-based nature interventions enhance adolescents' physical activity, social interaction, and psychological well-being, particularly when implemented as structured and meaningful experiences rather than passive exposure.

Furthermore, integrating ecological literacy with evidence-based psychoeducation, digital health promotion, healthy lifestyle interventions, and family-centered education may provide a more comprehensive strategy for improving adolescent mental health and promoting sustainable health outcomes in the digital era.

SUGGESTION

Based on the findings of this literature review, several recommendations can be proposed to strengthen adolescent mental health promotion in the digital era. First, schools are encouraged to integrate structured mental health literacy programs with digital literacy education to help adolescents develop self-regulation skills in managing social media use and reducing psychological risks such as anxiety, stress, and low self-esteem.

Second, educational institutions and policymakers should consider incorporating nature-based interventions into school activities, such as outdoor learning, school gardening, and regular engagement with green spaces. These activities should emphasize meaningful and active interaction with nature to strengthen emotional connectedness and improve psychological well-being.

Third, families play an essential role in providing supervision, emotional support, and guidance in adolescents' digital behavior. Parental involvement is needed to reduce the negative impact of excessive social media exposure and to support healthier coping strategies.

Finally, future research is recommended to employ longitudinal and experimental designs to better understand causal relationships between digital exposure, nature connectedness, and adolescent mental health. Cross-cultural validation of ecological literacy and nature connectedness instruments is also necessary to improve the generalizability of findings across different sociocultural contexts.

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