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ZAMONAVIY TA'LIMDA ISLOHOTLAR VA TEXNIK TAFAKKUR

ilmiy jurnali

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“ZAMONAVIY TA'LIMDA ISLOHOTLAR VA TEXNIK TAFAKKUR”

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FROM INDUSTRIAL SULFUR RESIDUES TO RELIABLE CROP PROTECTION: FEEDSTOCK QUALIFICATION, FORMULATION CONSISTENCY AND FIELD VALIDATION

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Abstract: A quality-oriented framework is proposed for converting industrial sulfur residues into crop-protection formulations. Recovery streams from oil and gas processing, sulfide-rich alkaline liquors and biological desulfurization are distinguished. Recent studies are evaluated alongside the 2025 FAO/WHO specification framework. The approach links feedstock qualification, uniform delivery and crop-specific validation. Scenario calculations show how reducing composition and mixing variability can improve consistency, while batch acceptance changes manufacturing cost. Published experimental findings are distinguished from the present analytical results. No new laboratory or field experiments are claimed.

Keywords: recovered sulfur; industrial residues; crop protection; batch qualification; delivery variability; field validation.

Аннотация: Предложена система разработки средств защиты растений из серосодержащих промышленных остатков с акцентом на стабильность качества. Учтены исследования 2024–2025 годов и подходы FAO/WHO. Расчётные сценарии связывают изменчивость состава и смешивания с однородностью дозирования, а долю годных партий — с затратами. Опубликованные экспериментальные результаты отделены от расчётов данной работы.

Ключевые слова: вторичная сера; промышленные отходы; защита растений; качество партий; изменчивость дозирования; полевые испытания.

Аннотация: Олтингугуртли саноат қолдиқларидан ўсимликлар ҳимояси воситаларини яратишда сифат барқарорлигига йўналтирилган тизим таклиф этилган. 2024–2025 йиллардаги тадқиқотлар ва FAO/WHO ёндашувлари ҳисобга олинган. Ҳисоблаш сценарийлари таркиб ва аралаштириш ўзгарувчанлигини дозалаш бир хиллиги билан боғлайди. Нашр этилган экспериментал натижалар ушбу иш ҳисобларидан ажратилган.

Калит сўзлар: иккиламчи олтингугурт; саноат қолдиқлари; ўсимликлар ҳимояси; партия сифати; дозалаш ўзгарувчанлиги; дала синовлари.

Introduction: The conversion of an industrial residue into an agricultural input is successful only when its performance can be reproduced. A sulfur-rich stream may have commercial potential, yet its origin, chemical composition and impurities can vary. Crop protection adds a further requirement: material must reach a defined biological target without unacceptable injury to the





crop. Recovery, formulation and agricultural use therefore represent connected but separate development problems.

The author-supplied background manuscript identifies local sulfur-containing resources and calcium-bearing minerals as possible inputs for plant-protection development [1]. This article extends that resource-oriented starting point by asking a different question: which evidence is needed before a secondary sulfur source can consistently replace a qualified technical ingredient? The objective is to establish an acceptance framework and quantify the sensitivity of delivery and production cost to variability.

2. Materials and analytical methods: A targeted comparison was made between the supplied background material, recent primary research and the FAO/WHO framework. The selected publications address phytomediated sulfur particles in 2024 [2], biochar–sulfur composites in 2025 [3], and sulfur applications in fruit orchards in 2024 [4]. Their findings were classified by the level of evidence: material characterization, laboratory biological activity or field response. Industrial recovery evidence [7–9] was additionally used to classify candidate waste streams. This is a focused synthesis.

Two independent calculations were developed. The first propagates variation in active-component concentration and local delivery through a multiplicative model. The second examines production cost per accepted batch under alternative acceptance and qualification scenarios. All numerical inputs are hypothetical and explicitly declared. They are not measurements of the local residue or an experimental formulation; calculations identify which parameters should be measured in subsequent development.

3. Results and discussion

3.1. Recent evidence and its limits of transfer

Ingle and colleagues investigated phytomediated zinc oxide and sulfur particles and their in vitro antifungal activity against organisms associated with ginger soft rot [2]. This work illustrates the need to connect particle characterization with a defined biological assay. It does not establish the performance of a waste-derived sulfur product, and the presence of both material classes requires careful attribution of individual effects. A synthesis route described as green is not, by itself, evidence of field suitability.

Peng and colleagues reported a biochar–sulfur composite with enhanced bactericidal activity against *Ralstonia solanacearum* and *Escherichia coli* [3]. Their reported fivefold enhancement and approximately 80% activity after five reuse cycles are results of that study. They demonstrate a promising material interaction, not a universal improvement factor for sulfur





formulations. Laboratory reuse also differs from persistence following agricultural spraying, where deposition, weathering and biological exposure operate differently.

Scaccini and colleagues tested sulfur-based treatments against *Halyomorpha halys* in apple and pear orchards [4]. Infestation was reduced, and apple damage assessments supported a protective effect. These findings broaden the research questions beyond conventional disease control. However, conclusions remain specific to the pest, formulations and experimental conditions. They do not justify describing sulfur as a general insecticide or transferring an orchard treatment programme to cotton without separate trials.

Taken together, these studies support a development strategy based on evidence progression rather than a single laboratory activity value. Modification may change dispersion, contact or biological interaction, but the benefit must survive storage, dilution and application. None of the cited studies characterizes the particular industrial residue described in the background material. Establishing that connection is the first unresolved research requirement.

3.2. Industrial waste streams and source-specific qualification

Three industrial streams are proposed for investigation. First, petroleum refineries and natural-gas-processing plants recover elemental sulfur during desulfurization; these sources are documented in the 2026 USGS sulfur summary [7]. Marketable recovered sulfur is often a by-product, whereas off-specification material and collection residues may require additional processing. Their status must be established for the actual stream. Hydrocarbon carryover, mineral contamination and moisture should be investigated according to its collection history.

Second, sulfide-rich spent alkaline liquors and industrial gas-scrubbing solutions are potential sulfur-recovery feedstocks, not ready-made crop treatments. Sergienko and colleagues demonstrated electrochemical conversion and recovery of elemental sulfur from sulfide-bearing solutions [8]. The relevant development route is controlled recovery, solid–liquid separation and purification before formulation. Residual alkalinity, salts, dissolved contaminants and any recovery reagents must be assessed. No direct application of untreated spent caustic is proposed, and recovery efficiency alone cannot establish agricultural suitability.

Third, biological desulfurization produces sulfur-rich suspensions or cakes. Mol and colleagues characterized sulfur formed at industrial biodesulfurization facilities [9]. This stream differs from conventional dry recovered sulfur in its formation and particle properties. Candidate preparation stages include dewatering, washing and conditioning, selected from actual analytical results. Biomass, residual salts, moisture and particle aggregation require investigation; biologically formed sulfur should not be assumed equivalent across plants or operating conditions.





The common qualification gates are verified chemical identity, an acceptable impurity profile and reproducible processing behavior. Total sulfur does not establish the amount of elemental sulfur available for a selected formulation. Feedstock records should identify the generating process, collection point and variability between batches. Limits and purification requirements must be justified for each source. Limestone described in the background manuscript remains a separate natural mineral input [1], not evidence that an industrial sulfur residue is suitable.

3.3. Consistency from the container to the crop surface

The relevant quality question is not simply whether a container contains the declared average amount of sulfur. It is whether representative portions deliver comparable amounts after preparation and application. Separation, incomplete redispersion and uneven mixing can create local differences despite an acceptable bulk assay. Formulation qualification should therefore include sampling after the intended handling procedure as well as direct analysis of the unopened product.

A practical test sequence compares the original material, stored product, freshly prepared dispersion and dispersion after a defined holding period. The sequence should record the analytical concentration and its spatial variability, together with observable separation and handling behavior. Water characteristics and mixing conditions must be reported. A result obtained under intensive laboratory mixing cannot automatically be extrapolated to preparation in farm equipment.

The 2025 third edition of the FAO/WHO manual provides the current specification framework and updates methodological references [5]. It supports aligning product identity, quality attributes and validated analytical methods. It should not be interpreted as proof that a particular waste-derived formulation is safe or effective. Numerical acceptance limits require justification for the intended product and method; unrelated specifications are not direct substitutes.

3.4. Calculated delivery variability

A normalized delivery index is defined as $q = a \cdot u$, where a is the active-component fraction relative to its declared value and u is a local delivery factor relative to the mean. Both factors are positive dimensionless variables. The model assumes independence and means of one. It describes relative variability, not a recommended pesticide dose and not biological efficacy.

For independent factors, $CVq^2 = CVa^2 + CVu^2 + CVa^2 \cdot CVu^2$, where CV denotes the coefficient of variation. The final term retains the interaction contribution of the multiplicative



model. Two illustrative conditions are compared in Table 1. The improved condition represents a proposed control objective, not an experimentally achieved result.

Table 1.

Hypothetical variability propagated to relative delivery

Condition	CVa	CVu	Calculated CVq
Initial variability	12%	10%	15.67%
Improved consistency	5%	4%	6.41%

Under these assumptions, reducing the two input variations lowers the delivery CV by approximately 59.1%. This result indicates that source consistency and mixing consistency should be addressed together. Improving only the chemical assay cannot remove variation caused by delivery. Conversely, better mixing cannot correct an incorrect average active-component content. If the two factors are correlated, the stated equation is insufficient and the joint distribution must be considered.

3.5. Acceptance yield and economic feasibility

Production performance can be evaluated by the fraction of batches that satisfy all release criteria. Let C be the average production and qualification cost per attempted batch, and p the acceptance fraction. For equal batch sizes, with rejected batches receiving no salvage credit, expected cost per accepted batch is C/p . This simple relation reveals the economic penalty of unreliable quality without assuming any particular market price.

Consider an illustrative initial process with $C = 100$ cost units and $p = 0.60$. Its expected cost is 166.67 units per accepted batch. A qualification improvement that raises C to 120 units while increasing p to 0.90 gives 133.33 units. The calculated reduction is 20%, despite a higher cost per attempt. These figures are hypothetical and do not constitute a business estimate for a local plant.

The break-even condition is $C_2/C_1 < p_2/p_1$. In the scenario, the acceptance ratio is 1.50, so the cost per attempt could rise by less than 50% while retaining an advantage under the stated assumptions. Real assessment must add rework, disposal, inventory, downtime and salvage value. Acceptance improvement cannot be assumed from tighter specifications alone: better process control must actually increase compliance.

3.6. A field-validation strategy

Field development should test the claim selected for the product rather than an undefined broad spectrum. A disease-control programme and a pest-behavior programme require different endpoints. Disease severity, pest density, feeding damage and crop injury must remain distinct



outcomes. Nutritional effects of sulfur should be assessed separately when they could influence plant growth or interpretation of crop response.

A useful comparison includes an untreated control, an auxiliary-only control, a qualified conventional sulfur formulation and the recovered-source candidate. Comparison at equal active-component loading helps distinguish source effects from differences in concentration. Additional comparisons can examine the intended commercial use, but that question should not be confused with ingredient equivalence. Multiple independently qualified production batches should enter the programme.

Sulfur programmes must also consider temperature, cultivar sensitivity and interactions with other treatments. UC IPM identifies crop-injury risks and restrictions around oil applications [6]. A development protocol should document relevant exposures and examine compatibility for its own formulation. Absence of visible damage in one assay does not establish safety for workers, beneficial organisms or subsequent applications.

4. Conclusions

A reliable recovered-sulfur product requires linked evidence at three levels: a qualified source, reproducible delivery and crop-specific performance. Recent studies strengthen the case for investigating modified sulfur materials, while also showing why laboratory improvement cannot substitute for field validation. The proposed framework organizes those requirements into a development sequence.

The analytical scenarios provide two distinct findings. First, combined control of composition and delivery variation can substantially improve consistency under explicit independence assumptions. Second, higher qualification expenditure can be economically justified when it increases the proportion of acceptable batches. Neither finding establishes pesticide efficacy; both identify measurable priorities for subsequent experiments.

The next research step is to characterize the actual industrial stream and estimate the model inputs from independent batches. Formulation testing and replicated crop trials can then determine whether recovered sulfur is technically comparable to a qualified conventional ingredient. Any publication of experimental efficacy should be based on those observations rather than on the scenarios presented here.

REFERENCES

1. Author-supplied manuscript on sulfur and local mineral resources for crop protection. Unpublished background material, file “Назирова (2).docx”.





2. Ingle P. U., Rai M., Golińska P., Gade A. K. Phytomediated zinc oxide and sulfur nanoparticles for management of soft-rot causing pathogenic fungi in ginger. *Biocatalysis and Agricultural Biotechnology*. 2024;58:103229. doi:10.1016/j.bcab.2024.103229.
3. Peng Y., Su L., Liu M., Zeng C., Xiang B., Xie Z., Hu Z., Zhou N. Biochar-Enhanced Sulfur: Mechanistic Insights into a Novel and Effective Bactericide. *Nanomaterials*. 2025;15(9):697. doi:10.3390/nano15090697.
4. Scaccini D., Fornasiero D., Lombardo V., Galli G., Mirandola E., Pozzebon A. Application of sulfur-based products reduces *Halyomorpha halys* infestation and damage in pome fruit orchards. *Pest Management Science*. 2024;80(12):6251–6261. doi:10.1002/ps.8354.
5. FAO; WHO. Manual on the development and use of FAO and WHO specifications for chemical pesticides. Third edition. 2025. Publication information: <https://extranet.who.int/prequal/vector-control-products/manuals-development-and-use-faowho-specifications-pesticides>.
6. University of California, UC IPM. Powdery Mildew on Fruits and Berries. <https://ipm.ucanr.edu/home-and-landscape/powdery-mildew-on-fruits-and-berries/>. Accessed 6 October 2026.
7. U.S. Geological Survey. Sulfur. Mineral Commodity Summaries 2026. <https://pubs.usgs.gov/periodicals/mcs2026/mcs2026-sulfur.pdf>.
8. Sergienko N., Cuervo Lumbaque E., Radjenovic J. (Electro)catalytic oxidation of sulfide and recovery of elemental sulfur from sulfide-laden streams. *Water Research*. 2023;245:120651. doi:10.1016/j.watres.2023.120651.
9. Mol A. R., van der Weijden R. D., Klok J. B. M., Buisman C. J. N. Properties of Sulfur Particles Formed in Biodesulfurization of Biogas. *Minerals*. 2020;10(5):433. doi:10.3390/min10050433.



ZAMONAVIY TA'LIMDA ISLOHOTLAR VA TEXNIK TAFAKKUR

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