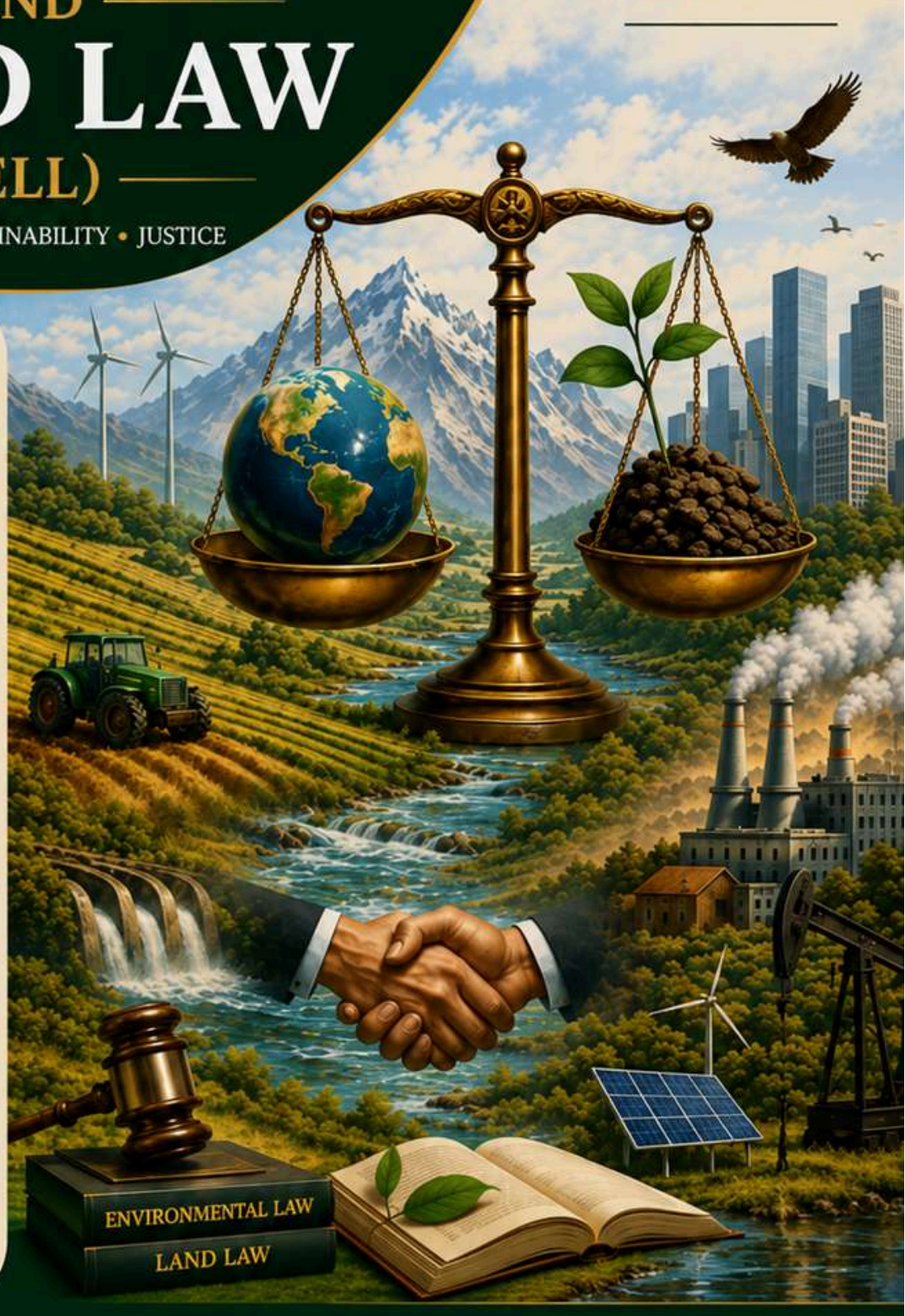
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Original research article

UTILIZATSIYA QILINADIGAN BEGONA O‘TLAR VA O‘SIMLIK QOLDIQLARIDAN TEZKOR CHIRINDI HOSIL QILISHNING INTELLEKTUAL TIZIMI

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MAQOLA MA’LUMOTI

Kalit so’zlar:
begona o‘tlar,
o‘simlik qoldiqlari,
kompostlash,
chirindi,
Noravshan boshqaruv,
intellektual tizim,
aeratsiya,
matematik model.

A N N O T A T S I Y A

Maqolada utilizatsiya qilinadigan begona o‘tlar va o‘simlik qoldiqlaridan tezkor chirindi (barqaror organik o‘g‘it) hosil qilish uchun intellektual boshqaruv tizimi taklif etilgan. Tizim reaktor ichidagi harorat, namlik va kislorod sharoitini datchiklar orqali o‘lchab, aeratsiya va suv berishni Noravshan (fuzzy) regulyator yordamida boshqaradi. Organik moddaning parchalanishi, issiqlik va namlik balansi matematik modeli asosida to‘rt ssenariy (passiv; o‘zgarmas aeratsiya; Noravshan boshqaruv; sanitariya bosqichli Noravshan boshqaruv) solishtirilgan. Shartli model hisobida Noravshan boshqaruv organik moddaning 50 % i parchalanish vaqtini 6,7 sutkagacha qisqartirgan, o‘zgarmas aeratsiya va namlik nazoratida bu ko‘rsatkich 16,8 sutkani tashkil etgan (60 % farq). Haroratga asoslangan sanitariya begona o‘tlar urug‘lari uchun kafolat bermasligi aniqlangan, shu sababli qabul mezoni sifatida germinatsiya sinovi tavsiya etiladi. Natijalar eksperimental tasdiqni talab qiladi.

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INTELLIGENT SYSTEM FOR THE RAPID FORMATION OF HUMUS FROM DISPOSABLE WEEDS AND PLANT RESIDUES

ARTICLE INFO

Keywords:
weeds,
plant residues,
composting,
humus,
fuzzy control,
intelligent system,
aeration,
mathematical model.

A B S T R A C T

This paper proposes an intelligent control system for the rapid production of humus-like organic fertiliser from weeds and plant residues destined for disposal. The system measures temperature, moisture and oxygen conditions in the reactor and controls aeration and watering with a fuzzy-logic controller. Four scenarios (passive; constant aeration; fuzzy control; fuzzy control with a sanitation stage) are compared using a mathematical model of organic matter degradation and heat and moisture balances. In the illustrative model simulation, fuzzy control reduced the time to 50 % degradation to 6.7 days, versus 16.8 days for constant aeration with moisture control (60 % difference). Temperature-based sanitation was found not to guarantee weed-seed inactivation, so a germination test is recommended as an acceptance criterion. The results require experimental validation.

ИНТЕЛЛЕКТУАЛЬНАЯ СИСТЕМА БЫСТРОГО ОБРАЗОВАНИЯ ГУМУСА ИЗ УТИЛИЗИРУЕМЫХ СОРНЯКОВ И РАСТИТЕЛЬНЫХ ОСТАТКОВ

ИНФОРМАЦИЯ СТАТЬИ

Ключевые слова:
сорняки, растительные остатки,
компостирование,
гумус,
нечёткое управление,
интеллектуальная система,
аэрация,
математическая модель.

А Н Н О Т А Т С И Я

В статье предложена интеллектуальная система управления для ускоренного получения гумусоподобного органического удобрения из сорняков и растительных остатков, подлежащих утилизации. Система измеряет температуру, влажность и кислородный режим в реакторе и управляет аэрацией и поливом с помощью нечёткого регулятора. На основе математической модели деградации органического вещества, теплового и влажностного балансов сопоставлены четыре сценария (пассивный; постоянная аэрация; нечёткое управление; нечёткое управление со стадией санитарной обработки). В условной модельной симуляции нечёткое управление сократило время 50 % деградации до 6,7 сут против 16,8 сут при постоянной аэрации с контролем влажности (разница 60 %). Показано, что температурная санитария не гарантирует инактивацию семян сорняков, поэтому в качестве критерия приёмки рекомендован тест на всхожесть. Результаты требуют экспериментального подтверждения.

KIRISH

Sug‘oriladigan yerlarda tuproq unumdorligining asosiy ko‘rsatkichi bo‘lgan chirindi miqdori intensiv ishlov berish va organik moddaning qaytarilmasligi natijasida kamayadi. Toshkent viloyatida 1926-yildan buyon olib borilayotgan uzoq muddatli tajribada o‘g‘itsiz nazorat variantida chirindi miqdori 96 yil davomida 54,3 % kamaygani qayd etilgan [1]. O‘zbekistonda o‘simlik qoldiqlarini mulcha sifatida qo‘llash va biochirindi kabi organik o‘g‘itlarni kiritish tuproqdagi organik modda miqdorini oshirishi ko‘rsatilgan [2], tuproq unumdorligini saqlash va oshirishda o‘simlik qoldiqlarini tuproqqa qaytarish hamda organik o‘g‘itlar tayyorlash dolzarb vazifa hisoblanadi [3]. Organik chiqindilarni qayta ishlashning asosiy usullaridan biri kompostlashdir [4, 5].

Begona o‘tlar yig‘ib olinib utilizatsiya qilinadigan biomassa manbai bo‘lib, ularni xom holda tuproqqa solish urug‘larning tarqalishi xavfini tug‘diradi. Begona o‘tlar urug‘larining hayotchanligini yo‘qotish uchun zarur bo‘lgan maksimal harorat turlarga qarab farq qiladi va isitish davomiyligidan ko‘ra muhimroq, shu sababli 65 °C da ushlab turiladigan kompostlash tizimlari begona o‘tlarni nazorat qilishning samarali usuli bo‘lmasligi mumkin [6]. Kompostlash jarayonini tezlashtirish uchun uzluksiz termofil kompostlash kabi yondashuvlar o‘rganilgan [7], aeratsiya va issiqlik olishni Noravshan mantiq asosida boshqarish tajribada termofil bosqichni qisqartirgan [8]. So‘nggi yillarda kompostlashda mashinali o‘qitish usullari tez rivojlanmoqda [9, 10], kompostlash texnologiyasi statik uyumdan intellektual reaktorgacha rivojlangani ta’kidlangan [11].

Tadqiqot bo‘shlig‘i. Ko‘rib chiqilgan manbalarda begona o‘tlar biomassasi, urug‘ sanitariyasi va intellektual boshqaruvni yagona tizimda birlashtirgan, O‘zbekiston sharoitiga moslashtirilgan ishlar topilmadi.

Maqsad: begona o‘tlar va o‘simlik qoldiqlaridan tezkor chirindi hosil qilishning intellektual boshqaruv tizimini ishlab chiqish va uning samaradorligini model orqali baholash.

Vazifalar: (1) tizim arxitekturasini tanlash; (2) organik modda parchalanishi, issiqlik va namlik balansi modelini tuzish; (3) Noravshan regulyatorni ishlab chiqish; (4) to‘rt ssenariyni solishtirish va sezgirlik tahlilini o‘tkazish.

Ilmiy yangilik: aeratsiya, suv berish va sanitariya bosqichini yagona Noravshan boshqaruv ostida birlashtirgan tizim taklif etilgan; haroratga asoslangan sanitariyaning begona o‘tlar urug‘lari uchun cheklovi model va adabiyot asosida ko‘rsatilgan.

ADABIYOTLAR TAHLILI

Kompostlash jarayonini modellashtirish. Mason kompostlash modellarini ko‘rib chiqib, issiqlik va massa balansi yondashuvlarini tizimlashtirgan [12]. Walling va boshq. so‘nggi 40 yillik adabiyotni tahlil qilib, modellar mikroorganizmlar o‘sishi va o‘lish tezligiga, iste'mol tezligi va mahsulot chiqishiga eng sezgir ekanligini, sun’iy intellekt va yetilishni modellashtirish rivojlanishi kerak bo‘lgan yo‘nalishlar ekanligini ko‘rsatgan [13]. Yang va boshq. 22 ta modelni ko‘rib chiqib, ularning 10 tasi mexanizmga asoslangan, 12 tasi ma’lumotga asoslangan ekanligini, ko‘pchiligi laboratoriya miqyosida ekanligini, birinchi tartibli kinetika esa harorat, kislorod, namlik va biologik parchalanuvchi uchuvchi qattiq moddaga bog‘liq ekanligini qayd etgan [14]. Aerob kompostlash modellari [15], substrat parchalanishi va kislorod iste’moli modeli [16], reaktor tipidagi kompostlashning massa-issiqlik-impuls uzatish modeli [17] va namlik o‘zgarishini bashorat qilish modellari [18] ishlab chiqilgan. Giusti va Marsili-Libelli kompostlash jarayonining Noravshan modelini taklif etgan [19].

Boshqaruv va intellektual tizimlar. Neugebauer va boshq. aeratsiya va issiqlik olishni Noravshan mantiq bilan boshqarib, optimal harorat 55 °C deb qabul qilgan va yangi o‘t hamda karam aralashmasida termofil bosqichni boshqarilmagan tajribalardagi 705 va 617 soatdan 288 soatdan kamgacha qisqartirgan [8]; bu harorat tanlovi MacGregor va boshq. ishiga asoslangan [20]. Su va boshq. tovuq go‘ngi fermentatsiyasida Noravshan harorat boshqaruvi bilan namlikni 70 % dan 30 % gacha kamaytirgan [21]. Balaganesh va boshq. IoT asosidagi tezkor kompostlagichda aralash organik chiqindilardan 28 kunda barqaror va yetilgan kompost olganini ma’lum qilgan [22]. Temel va boshq. kompostlashda sun’iy neyron tarmoqlar, tasodifiy o‘rmon, ANFIS, tayanch vektor mashinasi va chuqur neyron tarmoqlar qo‘llanilishini ko‘rib chiqqan [9]; Guo va boshq. organik qattiq chiqindilarni qayta ishlash jarayonlarini bashorat qilishda mashinali o‘qitish usullarini tahlil qilgan [10].

Yetilganlik va sifat mezonlari. Bernal va boshq. kompost yetilganligini baholash uchun kimyoviy mezonlar va chirindi hosil bo‘lishi masalalarini, shuningdek yetilganlik ko‘rsatkichlarini standartlashtirish zarurligini ko‘rsatgan [23]. Kompostlashda uglerod yo‘qotilishi 30–63 % oralig‘ida bo‘lishi ma’lum [24].

1-jadval. Adabiyotlarning qiyosiy tahlili

Manba	Substrat / obyekt	Yondashuv	Asosiy natija
[1]	Tuproq (Toshkent viloyati)	96 yillik dala tajribasi	O‘g‘itsiz variantda chirindi 54,3 % kamaygan
[2, 3]	Sug‘oriladigan tuproqlar	O‘simlik qoldiqlari mulchasi, organik o‘g‘itlar	Organik modda va unumdorlik oshgan
[6]	Begona o‘tlar urug‘lari	Haroratning hayotchanlikka ta’siri	65 °C kompostlash begona o‘tni nazorat qilishda samarasiz bo‘lishi mumkin
[7]	Shahar organik chiqindisi	Uzluksiz termofil kompostlash	Tez parchalanish va yetilish
[8]	Yangi o‘t + karam	Noravshan boshqaruv (aeratsiya, issiqlik olish)	Termofil bosqich 705 / 617 soatdan < 288 soatgacha
[14]	22 model	Mexanizmli (10) va ma’lumotli (12)	Ko‘pchiligi laboratoriya miqyosida
[21]	Tovuq go‘ngi	Arduino va Noravshan harorat boshqaruvi	Namlik 70 % dan 30 % gacha
[22]	Aralash organik chiqindi	IoT tezkor kompostlagich	28 kunda yetilgan kompost

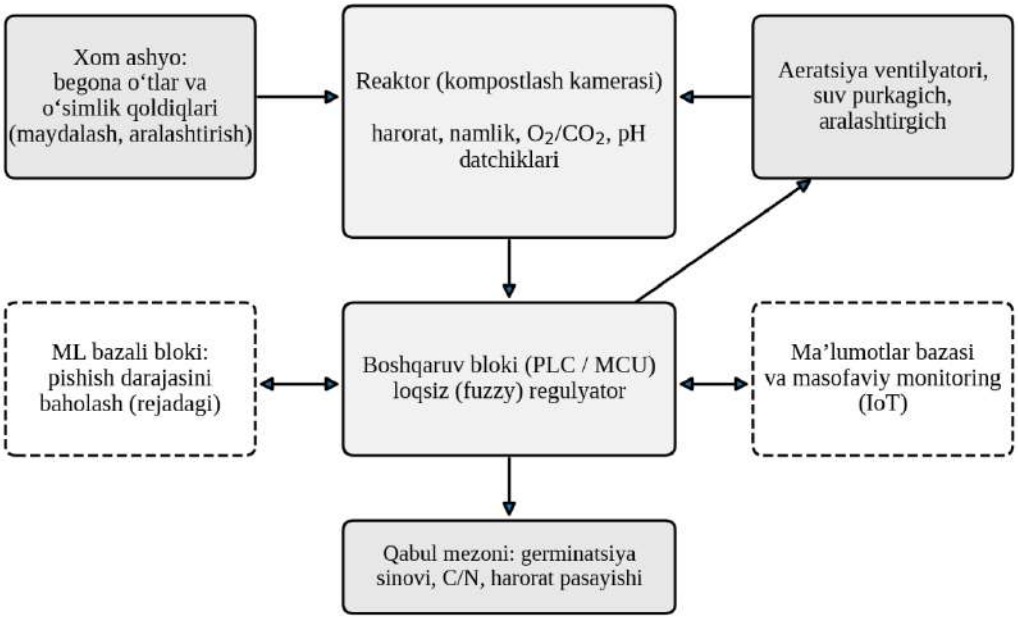
Tahlil shuni ko‘rsatadiki, mavjud ishlar boshqaruvni asosan harorat bo‘yicha olib boradi, begona o‘tlar urug‘larining sanitariyasi esa alohida muammo bo‘lib qolmoqda; O‘zbekiston ishlari asosan tuproq unumdorligi va organik o‘g‘itlar samarasiga qaratilgan [1–3].

METODOLOGIYA

Tizim arxitekturasi

Taklif etilgan tizim (1-rasm) xom ashyoni maydalab aralashtirish, datchikli reaktor, PLC/mikrokontrollerdagi Noravshan regulyator, ijrochi qurilmalar (aeratsiya ventilyatori, suv purkagich, aralashtirgich) va qabul mezoni blokidan iborat. Ma’lumotlar bazasi va mashinali o‘qitishga asoslangan yetilganlik bahosi bloki rejalashtirilgan va quyidagi hisobda ishlatilmagan.

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1-rasm. Intellektual kompostlash tizimining strukturaviy sxemasi

Parchalanish, issiqlik va namlik balansi modeli

Biologik parchalanuvchi uchuvchi qattiq modda S ning parchalanishi birinchi tartibli kinetika bilan tavsiflanadi; tezlik harorat, namlik va kislorod bilan cheklanadi [14]:

$$\frac{dS}{dt} = -k\, f_T(T)\, f_M(M)\, f_O(u)\, S \qquad (1)$$

$$f_T(T) = \exp\left[-\left(\frac{T - T_{opt}}{\sigma_T}\right)^2\right], \quad \sigma_T = \begin{cases}\sigma_1, & T \le T_{opt},\\ \sigma_2, & T > T_{opt},\end{cases} \qquad (2)$$

$$f_M(M) = \exp\left[-\left(\frac{M - M_o}{\sigma_M}\right)^2\right], \quad f_O(u) = \frac{u}{u + K_O} \qquad (3)$$

bu yerda k – maksimal solishtirma parchalanish tezligi, 1/soat; f_T, f_M, f_O – harorat, namlik va kislorod ta’minoti omillari (o‘lchamsiz); T – massa harorati, °C; T_{opt} – optimal harorat, °C; σ_1, σ_2 – optimumdan past va yuqori haroratlardagi egrilik parametrlari, °C; M – namlik (ho‘l og‘irlikka nisbatan, nisbiy birlik); M_o – optimal namlik; σ_M – namlik bo‘yicha egrilik parametri; u – havo sarfi, m³/soat; K_O – yarim to‘yinish sarfi, m³/soat. Omillarning Gauss shakli model tanlovi bo‘lib, kalibrovka talab qiladi.

Issiqlik balansi:

$$c_p \frac{dT}{dt} = Q_{gen} - Q_{air} - Q_{ev} - Q_{loss} \qquad (4)$$

$$Q_{gen} = h_{VS}\, r, \quad r = -\frac{dS}{dt} \qquad (5)$$

$$Q_{air} = \rho_a c_a\, u\,(T - T_{amb}), \quad Q_{ev} = L\,\rho_a\, u\,[w_s(T) - w_{in}], \quad Q_{loss} = UA\,(T - T_{amb}) \qquad (6)$$

$$w_s(T) = \frac{0{,}622\, p_s(T)}{P - p_s(T)}, \quad p_s(T) = 0{,}6112\exp\left(\frac{17{,}62\, T}{243{,}12 + T}\right) \qquad (7)$$

bu yerda c_p – massaning issiqlik sig‘imi, kJ/K; Q_{gen} – biologik issiqlik ajralishi, kJ/soat; h_{VS} – 1 kg uchuvchi modda parchalanganda ajraladigan issiqlik, kJ/kg; r – parchalanish tezligi, kg/soat; Q_{air} – havo bilan olib ketiladigan sezgir issiqlik; Q_{ev} – bug‘lanishga sarflanadigan issiqlik; Q_{loss} – reaktor devori orqali yo‘qotish, kJ/soat; ρ_a – havo zichligi, kg/m³; c_a – havoning solishtirma issiqlik sig‘imi, kJ/(kg·K); L – bug‘lanish issiqligi, kJ/kg; w_s va w_{in} – chiqayotgan (to‘yingan) va kirayotgan havoning namlik saqlashi, kg/kg; UA – issiqlik yo‘qotish koeffitsiyenti, kJ/(soat·K); T_{amb} – atrof-muhit harorati, °C; p_s – to‘yingan bug‘ bosimi, kPa (Magnus formulasi); P – atmosfera bosimi, kPa.

Namlik balansi:

$$\frac{dW}{dt} = -\dot{m}_{ev} + y_w\, r + \dot{m}_{dos}, \quad M = \frac{W}{W + D}, \quad D = D_0 - (S_0 - S) \qquad (8)$$

bu yerda W – suv massasi, kg; $\dot{m}_{ev} = \rho_a u[w_s(T) - w_{in}]$ – bug‘lanish tezligi, kg/soat; y_w – 1 kg parchalangan modda hisobiga hosil bo‘ladigan metabolik suv, kg/kg; $\dot{m}_{dos}$ – dozalanadigan suv, kg/soat; D – quruq massa, kg; indeks 0 boshlang‘ich qiymatni bildiradi.

Noravshan (fuzzy) regulyator

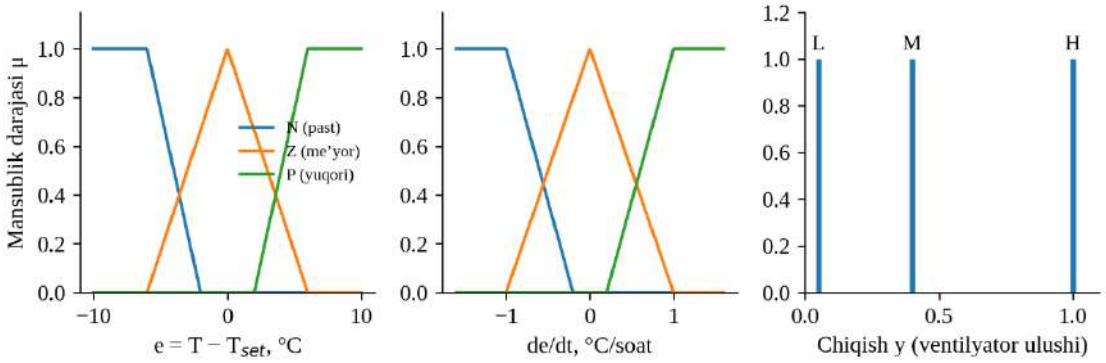
Regulyatorning kirishlari – harorat xatosi $e = T - T_{set}$ (°C) va uning o‘zgarish tezligi $\dot{e} = dT/dt$ (°C/soat, boshqaruv davri ichida hisoblanadi); chiqishi – ventilyator quvvati ulushi $y \in [0; 1]$. Kirishlar uchta tilshunoslik to‘plami (N – past, Z – me'yor, P – yuqori) bilan, chiqish L, M, H nuqtaviy to‘plamlar (0,05; 0,40; 1,00) bilan tavsiflangan (2-rasm). Qoidalar bazasi 2-jadvalda keltirilgan; chiqish og‘irlik markazi usuli bilan hisoblanadi [8]:

$$y = \frac{\sum_r w_r\ y_r}{\sum_r w_{\,r}}, \quad w_r = \min\left(\mu_{e,r}, \mu_{\dot{e},r}\right) \qquad (9)$$

$$u = u_0 + u_{max}\, y \qquad (10)$$

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bu yerda y_r – r-qoida chiqish qiymati; w_r – qoida faollik darajasi; μ – mansublik darajasi; u_0 – minimal (tabiiy) havo sarfi, m³/soat; u_{max} – ventilyatorning maksimal sarfi, m³/soat. Boshqaruv davri 1 soat, chiqish signali yengil filtrlangan ($y_k = 0{,}5\, y_{k-1} + 0{,}5\, y_k^*$). Namlik M 0,52 dan pastga tushsa, M 0,55 ga yetguncha suv dozalanadi.



2-rasm. Noravshan (fuzzy) regulyatorning mansublik funksiyalari

2-jadval. Noravshan regulyator qoidalar bazasi (chiqish y)

e ė	N	Z	P
N	L	L	L
Z	L	M	H
P	M	H	H

Muvaffaqiyat mezoni sifatida organik moddaning parchalanish darajasi qabul qilingan:

$$X(t) = 1 - \frac{S(t)}{S_0}, \qquad X(t_{50}) = 0{,}5 \qquad (11)$$

bu yerda X – parchalanish darajasi (nisbiy birlik); t_{50} – X 50 % ga yetgan vaqt, sutka. 50 % chegarasi shartli qabul qilingan; haqiqiy yetilganlik germinatsiya indeksi, C/N va boshqa kimyoviy mezonlar bilan tasdiqlanishi kerak [23].

Simulyatsiya sharoitlari

Hisob 500 kg ho‘l massali reaktor uchun 0,05 soat qadam bilan 30 sutka davomida bajarildi. Parametrlar 3-jadvalda keltirilgan; ular tushuntirish maqsadida shartli tanlangan va eksperimentda kalibrovka qilinishi kerak. Ssenariylar: **A** – passiv (havo sarfi 0.3 m³/soat, suv berilmaydi); **B** – o‘zgarmas aeratsiya (3 m³/soat), suv berilmaydi; **B2** – o‘zgarmas aeratsiya va namlik nazorati; **C** – Noravshan boshqaruv (T_{set} = 55 °C) va namlik nazorati; **D** – C ga

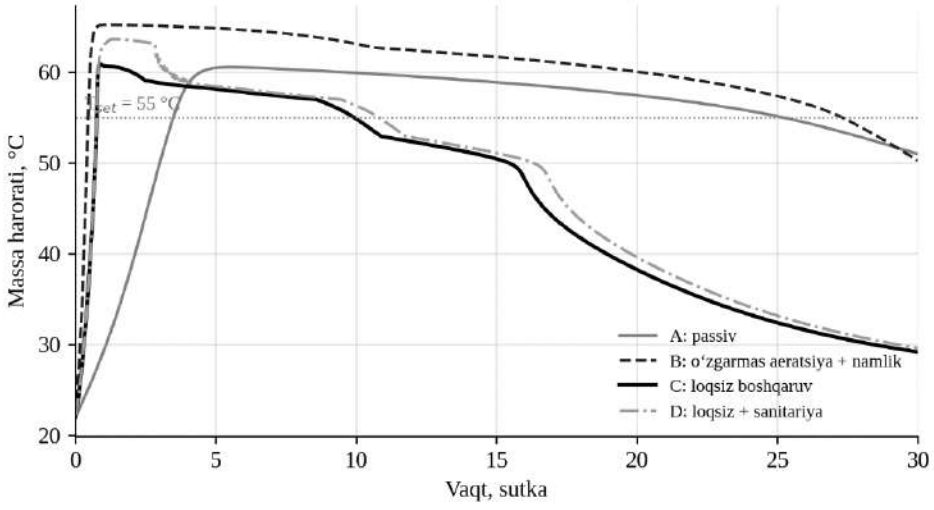
sanitariya bosqichi qo‘shilgan (harorat birinchi marta 60 °C ga yetgach, 48 soat davomida T_{set} = 65 °C, so‘ng 55 °C).

3-jadval. Modelning shartli kirish parametrlari

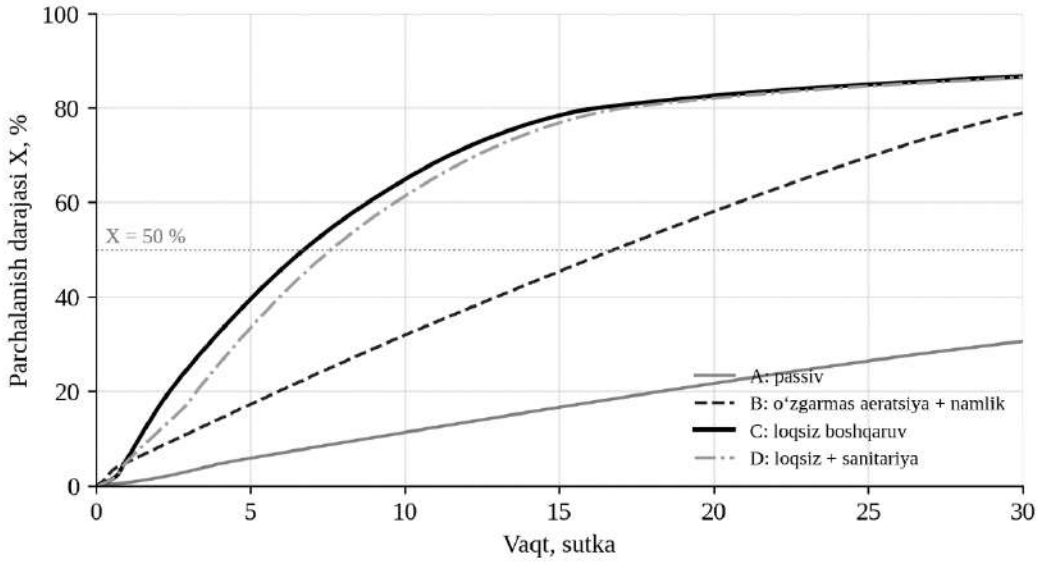
Parametr	Qiymat
Uchuvchi modda S_0 / quruq massa D_0 / suv W_0	160 kg / 200 kg / 300 kg (M_0 = 0.60)
Solishtirma tezlik k	0,008 1/soat
T_{opt}, σ_1, σ_2	55 °C, 30 °C, 10 °C
M_o, σ_M	0,58; 0,12
K_O	3 m³/soat
h_{VS} / y_w	14000 kJ/kg / 0,5 kg/kg
UA / T_{amb}	22 kJ/(soat·K) / 20 °C
u_0 / u_{max}	0.3 / 20 m³/soat
Namlik chegaralari / suv dozasi	0,52–0,55 / 1.5 kg/soat
Havo: ρ_a, c_a, L, w_{in}	1,2 kg/m³; 1,006 kJ/(kg·K); 2400 kJ/kg; 0.0073 kg/kg

NATIJALAR VA MUHOKAMA

Quyidagi natijalar tuzilgan model bo‘yicha hisoblangan (shartli hisob-kitob) va eksperimental tasdiq o‘rnini bosmaydi. Haroratning o‘zgarishi 3-rasmda, parchalanish darajasi 4-rasmda, ko‘rsatkichlar 4-jadvalda berilgan.



3-rasm. Ssenariylar bo‘yicha massa harorati (shartli model hisobi)



4-rasm. Organik moddaning parchalanish darajasi (shartli model hisobi)

4-jadval. Ssenariylar natijalari (30 sutka, shartli model hisobi)

Ko‘rsatkich	A	B	B2	C	D
t_{50}, sutka	> 30	20,5	16,8	6,7	7,6
X 30-sutkada, %	31	52	79	87	86
Maksimal harorat, °C	60,5	65,2	65,2	60,9	63,6
$T \geq 55$ °C, soat	521	356	644	220	241
$T \geq 60$ °C, soat	117	303	469	28	60
$T \geq 65$ °C, soat	0	68	68	0	0
Havo hajmi, m³	216	2160	2160	4056	3888
Qo‘shilgan suv, kg	0	0	119	249	241

MUHOKAMA

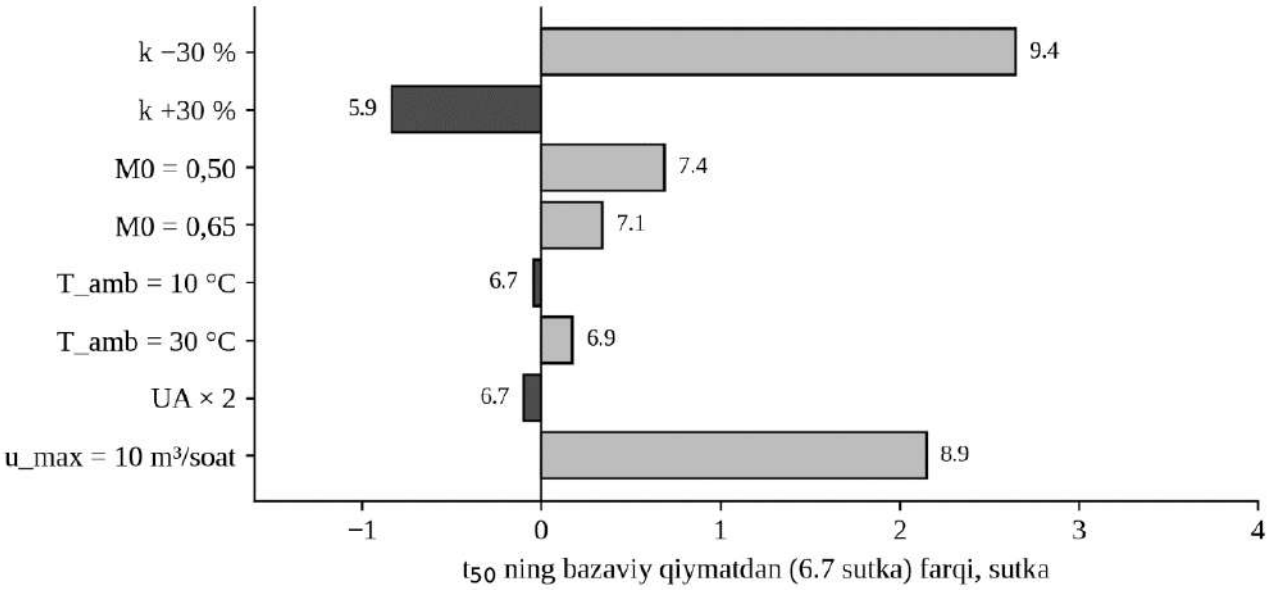
Noravshan boshqaruv (C) t_{50} ni 6,7 sutkagacha qisqartirdi, bu o‘zgarmas aeratsiya va namlik nazoratidagi (B2, 16,8 sutka) ssenariydan 60 % tez; evaziga havo hajmi 1,9 marta ko‘p (4056 va 2160 m³). B va B2 farqi (namlik nazorati) boshqaruvning hissasini aeratsiyadan

ajratib ko‘rsatadi. Passiv ssenariyda (A) harorat 521 soat 55 °C dan yuqori bo‘lsa ham, parchalanish 30 sutkada 31 % ga yetdi: tezlikni harorat emas, kislorod ta’minoti cheklagan ($f_O \approx 0{,}09$), ya’ni harorat o‘zi jarayon holatining yetarli ko‘rsatkichi emas. O‘zgarmas aeratsiyada (B, B2) massa harorati 65,2 °C gacha ko‘tarilib, 68 soat 65 °C dan yuqori bo‘ldi, bu holatda $f_T \approx 0{,}37$ ga pasayadi. Yo‘nalish jihatdan bu natija Neugebauer va boshq. tajribalariga mos keladi: boshqarilmagan sharoitda termofil bosqich uzoq, Noravshan boshqaruvda qisqa bo‘lgan [8], biroq substrat va miqyos farqi tufayli sonlar solishtirilmaydi. Bizning modelda ham $T \geq 55$ °C davomiyligi C ssenariyda (220 soat) B2 ga (644 soat) nisbatan qisqa.

Sanitariya bosqichi (D) t_{50} ni C ga nisbatan 0,9 sutkaga uzaytirdi, $T \geq 60$ °C vaqtini 28 soatdan 60 soatgacha oshirdi, lekin 65 °C ga erishilmadi (maksimum 63,6 °C): yuqori haroratda mikrobial faollik pasayib, issiqlik ajralishi sanitariya setpointini ushlab turishga yetmadi. Begona o‘tlar urug‘larining hayotchanligini yo‘qotish harorat bo‘yicha turlarga bog‘liq va 65 °C da ham kafolatlanmaydi [6], shuning uchun tizimda harorat sanitariyasiga tayanib bo‘lmaydi. Muhandislik tavsiyasi sifatida (adabiyot bilan tasdiqlanmagan taxmin) qabul mezoni sifatida tayyor mahsulotda urug‘lar germinatsiya sinovi o‘tkazilishi, begona o‘tlarni urug‘ hosil qilishdan oldin yig‘ish va xom ashyoni maydalash ko‘rib chiqilishi kerak.

5-jadval. Sezgirlik tahlili (C ssenariy, t_{50}, sutka)

Parametr o‘zgarishi	t_{50}	Bazadan farq
Baza (k = 0,008 1/soat)	6,7	0,0
k −30 %	9,4	+2,7
k +30 %	5,9	−0,8
M_0 = 0,50	7,4	+0,7
M_0 = 0,65	7,1	+0,4
T_{amb} = 10 °C	6,7	0,0
T_{amb} = 30 °C	6,9	+0,2
UA × 2	6,7	0,0
u_{max} = 10 m³/soat	8,9	+2,2



5-rasm. t_{50} ning parametrlar o‘zgarishiga sezgirligi (C ssenariy)

Eng katta ta’sirni solishtirma tezlik k ko‘rsatdi (k ni 30 % kamaytirish t_{50} ni 9,4 sutkagacha uzaytirdi), bu modellar mikroorganizmlar o‘sish tezligiga eng sezgir ekanligi haqidagi sharh xulosasiga mos keladi [13]. Ventilyator quvvatini kamaytirish (u_{max} = 10 m³/soat) ham t_{50} ni 8,9 sutkagacha oshirdi, ya’ni jarayon kislorod ta’minoti bilan cheklangan. Boshlang‘ich namlik va atrof harorati ta’siri kichik, chunki namlik nazorati va issiqlik balansi bu o‘zgarishlarni qoplaydi.

Cheklovlar. Natijalar kalibrovka qilinmagan modelga asoslangan; ular parametrlar tanloviga bog‘liq va tajriba bilan tasdiqlanmagan. Mashinali o‘qitishga asoslangan yetilganlik bahosi bloki hisobga olinmagan. Model begona o‘tlar urug‘larining hayotchanligini hisoblamaydi.

XULOSA VA AMALIY TAVSIYALAR

Begona o‘tlar va o‘simlik qoldiqlaridan tezkor chirindi hosil qilish uchun Noravshan regulyatorli intellektual tizim taklif etildi va parchalanish, issiqlik hamda namlik balansi modeli asosida baholandi. Shartli model hisobida Noravshan boshqaruv organik moddaning 50 % i parchalanishini 6,7 sutkada ta’minladi, o‘zgarmas aeratsiya va namlik nazoratida bu 16,8 sutka, o‘zgarmas aeratsiyada namliksiz 20,5 sutka bo‘ldi, passiv rejimda esa 30 sutkada 31 % parchalandi. Tezlashuv havo hajmining 1,9 barobar ortishi hisobiga erishildi. Sanitariya bosqichi jarayonni 0,9 sutkaga sekinlashtirdi va 65 °C ga erishilmadi, shu sababli begona o‘tlar

urug‘lari uchun harorat kafolati yo‘q. Eng sezgir parametrlar solishtirma parchalanish tezligi va ventilyator quvvati bo‘ldi.

Tavsiyalar: (1) modelni 0,5–1 m³ hajmli tajriba reaktorida kalibrovka qilish; (2) tayyor mahsulotda begona o‘tlar urug‘larining germinatsiya sinovini majburiy qabul mezoni qilish; (3) ventilyator quvvatini jarayon cho‘qqisidagi issiqlik ajralishiga mos tanlash; (4) yetilganlikni baholash uchun kimyoviy mezonlar bilan birga mashinali o‘qitish blokini keyingi bosqichda qo‘shish.

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